[*Frontispiece, Vol. xxxiv.*]

CHARLES EDWARD RHODES,

PRESIDENT OF THE INSTITUTION OF MINING ENGINEERS, 1907-1908.

TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

VOL. XXXIV.—1907-1908.

EDITED BY PERCY STRZELECKI, SECRETARY *pro tem.*

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTION.

PRINTED BY ANDREW REID & CO., LIMITED, NEWCASTLE-UPON-TYNE.
1908.

ADVERTISEMENT.

The Institution, as a body, is not responsible for the statements and opinions advanced in the papers which may be read or in the discussions which may take place at the meetings of the Institution or of the Federated Institutes.

CONTENTS OF VOL. XXXIV.

GENERAL MEETINGS.

THE INSTITUTION OF MINING ENGINEERS.

THE INSTITUTION OF MINING ENGINEERS.—*Continued.*

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS AND THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE INSTITUTE OF MINING ENGINEERS.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

THE MINING INSTITUTE OF SCOTLAND.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—*Continued.*

THE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE INSTITUTE OF MINING ENGINEERS.

APPENDICES.

APPENDICES.—*Continued.*

LIST OF PLATES:—

ANY PUBLICATION OF A FEDERATED INSTITUTE MAY BE PLACED AT THE END OF THE VOLUME, *e.g.*, "ANNUAL REPORT," "LIST OF MEMBERS," ETC.

THE INSTITUTION OF MINING ENGINEERS.

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* Deceased.

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Mr. Arthur Nicholas Lindsay Wood, The Hermitage, Chester-le-Street.

Auditors.

Messrs. John G. Benson and Sons, Newcastle-upon-Tyne.

Treasurers.

Lloyds Bank Limited, Lambton's Branch, Grey Street, Newcastle-upon-Tyne.

Secretary.

*Mr. Martin Walton Brown, Neville Hall, Newcastle-upon-Tyne.

Secretary pro tem.

Mr. Percy Strzelecki, Neville Hall, Newcastle-upon-Tyne.

THE INSTITUTION OF MINING ENGINEERS.

FOUNDED JULY 1ST, 1889.

BYE-LAWS.

As revised at Council Meeting held on January 15th, 1908.

I.—CONSTITUTION.

1.—The Institution of Mining Engineers shall consist of all or any of the societies interested in the advancement of mining, metallurgy, engineering and their allied industries, who shall from time to time join together and adhere to the bye-laws.

2.—The Institution shall have for its objects—

(a) The advancement and encouragement of the sciences of mining, metallurgy, engineering, and their allied industries.

(b) The interchange of opinions, by the reading of communications from members and others, and by discussions at general meetings, upon improvements in mining, metallurgy, engineering, and their allied industries.

(c) The publication of original communications, discussions, and other papers connected with the objects of the Institution.

(d) The purchase and disposal of real and personal property for such objects.

(e) The performance of all things connected with or leading to the purpose of such objects.

3.—The offices of the Institution shall be in Newcastle-upon-Tyne, or such other place as shall be from time to time determined by resolution of the Council.

4.—The year of the Institution shall end on July 31st in every year.

5.—The affairs and business of the Institution shall be managed and controlled by the Council.

II.—MEMBERSHIP.

6.—The original adherents or founders are as follows:—

(a) Chesterfield and Midland Counties Institution of Engineers, Chesterfield.

(b) Midland Institute of Mining, Civil and Mechanical Engineers, Barnsley.

(c) North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

(d) South Staffordshire and East Worcestershire Institute of Mining Engineers, Birmingham.

7.—Written applications from societies to enter the Institution shall be made to the Council, by the President of the applying society, who shall furnish any information that may be desired by the Council.

8.—A.—If desired by the Council, any of the Federated Institutes shall revise their bye-laws, in order that their members shall consist of Ordinary Members, Associate Members, and Honorary Members, with Associates and Students, and section B following shall be a model bye-law to be adopted by any society when so desired by the Council.

B.—" The members shall consist of Ordinary Members, Associate Members and Honorary Members, with Associates and Students:—

(a) Each Ordinary Member shall be more than twenty-three years of age, have been regularly educated as a mining, metallurgical, or mechanical engineer, or in some other branch of engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an engineer; or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an engineer for at least five years.

(b) Each Associate Member shall be a person connected with or interested in mining, metallurgy, engineering, or geology, and not practising as a mining, metallurgical or mechanical engineer, or some other branch of engineering, or as a geologist.

(c) Each Honorary Member shall be a person who has distinguished himself by his literary or scientific attainments, or who may have made important communications to any of the Federated Institutes.

(d) Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines or metallurgical works, or employed in analogous positions in other branches of engineering.

(e) Students shall be persons who are qualifying themselves for the profession of mining, metallurgical, or mechanical engineering, or other branch of engineering, and such persons may continue Students until they attain the age of twenty-five years."

9.—The Ordinary Members, Associate Members and Honorary Members, Associates and Students shall have notice of, and the privilege of attending, the ordinary and annual general meetings, and shall receive all publications of the Institution. They may also have access to, and take part in, the general meetings of any of the Federated Institutes.

10.—The members of any Federated Institute, whose payments to the Institution are in arrear, shall not receive the publications and other privileges of the Institution.

11.—After explanations have been asked by the President from any Federated Institute, whose payments are in arrear, and have not been paid within one month after written application by the Secretary, the Council may decide upon its suspension or expulsion from the Institution; but such suspension or expulsion shall only be decided at a meeting attended by at least two-thirds of the members of the Council by a majority of three-fourths of the members present.

III.—Subscriptions.

12.—Each of the Federated Institutes shall pay fifteen shillings per annum for each Ordinary Member, Associate Member, Honorary Member, Associate and Student, or such other sum, and in such instalment or instalments as may be determined from time to time by resolution or resolutions of the Council. Persons joining any of the Federated Institutes during the financial year of the Institution shall be entitled to all publications issued for that year, after his election is notified to the Secretary, and the instalment or instalments due on his behalf have been paid.

IV.—Election of Officers and Council.

13.—The officers of the Institution, other than the Secretary and Treasurer, shall consist of Councillors elected annually prior to August in each year, by and out of the Ordinary Members and Associate Members of each Federated Institute, in the proportion of one Councillor per forty Ordinary Members or Associate Members thereof; of Vice-Presidents elected by and from the Council at their first meeting in each year on behalf of each Institute, in the proportion of one Vice-President per two hundred Ordinary Members or Associate Members thereof; and of a President elected by and from the Council at their first meeting in each year; who, with the Local Secretaries of each Federated Institute and the Secretary and Treasurer, shall form the Council. All Presidents on retiring from that office shall be *ex-officio* Vice-Presidents so long as they continue Ordinary Members or Associate Members of any of the Federated Institutes.

14.—In case of the decease, expulsion, or resignation of any officer or officers, the Council may, if they deem it requisite, fill up the vacant office or offices at their next meeting.

V.—Duties of Officers and Council.

15.—The Council shall represent the Institution and shall act in its name, and shall make such calls upon the Federated Institutes as they may deem necessary, and shall transact all business and examine accounts, authorise payments and may invest or use the funds in such manner as they may from time to time think fit, in accordance with the objects and bye-laws of the Institution.

16.—The Council shall decide the question of the admission of any society, and may decree the suspension or expulsion of any Federated Institute for non-payment of subscriptions.

17.—The Council shall decide upon the publication of any communications.

18.—There shall be three ordinary meetings of the Council in each year, on the same day as, but prior to, the ordinary or annual general meetings of the members.

19.—A special meeting of the Council shall be called whenever the President may think fit, or upon a requisition to the Secretary signed by ten or more of its members, or by the President of any of the Federated Institutes. The business transacted at a special meeting of the Council shall be confined to that specified in the notice convening it.

20.—The meetings of the Council shall be called by circular letter, issued to all the members at least seven days previously, accompanied by an agenda-paper, stating the nature of the business to be transacted.

21.—The order in which business shall be taken at the ordinary and annual general meetings may be, from time to time, decided by the Council.

22.—The Council may communicate with the Government in cases of contemplated or existing legislation, of a character affecting the interests of mining, metallurgy, engineering, or their allied industries.

23.—The Council may appoint Committees, consisting of members of the Institution, for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institution.

24.—A Committee shall not have power or control over the funds of the Institution, beyond the amount voted for its use by the Council.

25.—Committees shall report to the Council, who shall act thereon and make use thereof as they may elect.

26.—The President shall take the chair at all meetings of the Institution, the Council, and Committees at which he may be present.

27.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institution. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any member of Council, or in case of their absence any Ordinary Member or Associate Member to take the chair at the meeting.

28.—At meetings of the Council six shall be a quorum.

29.—Every question shall be decided at the meetings of the Council by the votes of the majority of the members present. In case of equal voting, the President, or other member presiding in his absence, shall have a casting vote. Upon the request of two members, the vote upon any question shall be by ballot.

30.—The Secretary shall be appointed by and shall act under the direction and control of the Council. The duties and salary of the Secretary shall be fixed and varied from time to time at the will of the Council.

31.—The Secretary shall summon and attend all meetings of the Council, and the ordinary and annual general meetings of the Institution, and shall record the proceedings in the minute book. He shall direct the administrative and scientific publications of the Institution. He shall have charge of and conduct all correspondence relative to the business and proceedings of the Institution, and of all committees where necessary, and shall prepare and issue all circulars to the members.

32.—One and the same person may hold the office of Secretary and Treasurer.

33.—The Treasurer shall be appointed annually by the Council at their first meeting in each year. The income of the Institution shall be received by him, and shall be paid into Messrs. Lambton & Co.'s bank at Newcastle-upon-Tyne, or such other bank as may be determined from time to time by the Council.

34.—The Treasurer shall make all payments on behalf of the Institution, by cheques signed by two members of Council, the Treasurer and the Secretary, after payments have been sanctioned by Council.

35.—The surplus funds may, after resolution of the Council, be invested in Government securities, in railway and other debenture shares such as are allowed for investment by trustees, in the purchase of land, or in the purchase, erection, alteration, or furnishing of buildings for the use of the Institution. All investments shall be made in the names of Trustees appointed by the Council.

36.—The accounts of the Treasurer and the financial statement of the Council shall be audited and examined by a chartered accountant, appointed by the Council at their first meeting in each year. The accountant's charges shall be paid out of the funds of the Institution.

37.—The minutes of the Council's proceedings shall at all times be open to the inspection of the Ordinary Members and Associate Members.

VI.—General Meetings.

38.—An ordinary general meeting shall be held in February, May and September, unless otherwise determined by the Council; and the ordinary general meeting in the month of September shall be the annual general meeting at which a report of the proceedings, and an abstract of the accounts of the previous year ending July 31st, shall be presented by the Council. The ordinary general meeting in the month of May shall be held in London, at which the President may deliver an address.

39.—Invitations may be sent by the Secretary to any person whose presence at discussions shall be thought desirable by the Council, and persons so invited shall be permitted to read papers and take part in the proceedings and discussions.

40.—Discussion may be invited on any paper published by the Institution, at meetings of any of the Federated Institutes, at which the writer of the paper may be invited to attend. Such discussion, however, shall in all cases be submitted to the writer of the paper before publication, and he may append a reply at the end of the discussion.

VII.—Publications.

41.—The publications of the Institution shall consist of the reports of the meetings of the Institution and of the meetings of the Federated Institutes, and abstracts of patents and other publications relating to mining, metallurgy and allied industries.

The reports of the meetings shall consist of addresses, papers, and the discussions thereon.

The publications may include:—

(a) Papers upon the working of mines, metallurgy, applied geology, engineering, railways and the various allied industries.
(b) Papers on the management of industrial operations.
(c) Abstracts of colonial and foreign papers upon similar subjects.
(d) Abstracts of patents relating to mining and metallurgy.
(e) Notes of questions of law concerning mines, manufactures, railways, etc.

The following shall be deemed unsuitable, and shall be refused:—

(a) Papers containing what is in fact advertising matter.
(b) Papers consisting largely of matter already printed in the English language.
(c) Papers consisting largely of matter foreign to the objects of the Institution or Federated Institutes.
(d) Papers containing matter the publication of which may be deemed injurious to the interests of the Institution or of any Federated Institute.
(e) Papers containing matter either libellous or slanderous, or gross misstatements.

42.—The Secretary of the Institution shall be responsible for the editing of the volumes as a whole, for the editing of the reports of the meetings of the Institution and of the Federated Institutes, and for the miscellaneous portion. The Local Secretary of each Federated Institute shall prepare and edit all papers and discussions of such Institute, and promptly forward them to the Secretary, who shall submit proofs to the Local Secretary before publication.

43.—The Council shall appoint a Publications Committee to deal with questions concerning the publications.

44.—A paper for reading at any of the meetings of the Institution shall be sent to the Secretary a clear six weeks before the meeting in question. The Secretary may refer a paper back to the author for compression or alteration, or, in case the matter be deemed suitable, but objection be taken to the mode of expression thereof, he may refer it back to the author for amendment in this respect. If the Author and Secretary cannot agree as to the suitability of the paper, the Secretary shall submit it to two members of the Publications Committee. If both of these approve or reject it, their decision shall be final, but if their views differ it shall be referred to the President of the Institution, whose decision shall be final.

A paper that has been submitted to and approved by the Council of a Federated Institute shall be sent to the Secretary of the Insitution a clear fortnight before the date of the meeting at which it is intended to be read, together with any drawings or illustrations which may be required to accompany it. If desired by the Secretary of the Federated Institute, the Secretary of the Institution will then have the paper printed in galley-form for distribution at the meeting. After the meeting, the paper, revised if necessary by the Secretary in question, shall be returned to the Secretary of the Institution in its final form ready for setting up in pages. If the Secretary of the Institution, at any time, considers the paper unsuitable for appearance in the *Transactions*, he shall notify the Secretary of the Federated Institute, and shall refer it to two members of the Institution Publications Committee, excluding the Secretary or member representing the Institute from which the paper proceeds. If, in the unanimous opinion of these members, the paper is unsuitable for appearance in the *Transactions*, it shall not appear in the *Transactions*, but if their views differ, it shall be referred to the President of the Institution, whose decision shall be final.

45.—Any discussion taking place at any meetings of the Institution shall be reported by a competent reporter. The proof of each speaker's remarks in the discussion shall be sent out to him by the Secretary of the Institution with an intimation that, if not returned corrected within seven days, it will be considered as correct, and the Secretary shall then edit the revised discussion.

The Federated Institutes shall make their own arrangements for reporting the discussions at their meetings and for the correction of the reports of the speakers. The Secretary of each Federated Institute shall forward a clear transcript of the discussion, edited by him, to the Secretary of the Institution for printing. Two galley proofs, together with the manuscript, shall be sent to the Secretary of the Federated Institute for correction, one of which, together with the manuscript, shall be returned ready for printing within seven days of receipt by him, failing which, it shall be considered to be correct.

46.—The Council may accept communications from persons who are not members of the Institution, and allow them to be read at the ordinary or annual general meetings of the Institution.

47.—A paper in course of publication cannot be withdrawn by the writer, without the permission of the Council.

48.—The copyright of all papers accepted for publication in the *Transactions* shall become vested in the Institution, and such communications shall not be published for sale or otherwise without the written permission of the Council.

49.—Thirty copies of each paper and the accompanying discussion shall be presented to the writer free of cost. He may also obtain additional copies upon payment of the cost to the Secretary, by an application attached to his paper. These copies must be unaltered copies of the paper as appearing in the publication of the Institution, and the copy shall state that it is an "Excerpt from the *Transactions* of The Institution of Mining Engineers."

50.—The Federated Institutes may receive copies of their own portion of the publications in respect of such of their members as do not become members of the Institution, and shall pay 10s. per annum in respect of every copy so supplied: and similar copies for exchange shall be paid for at cost price.

51.—A list of the members, with their last-known addresses, indicating the Federated Institute to which they belong, shall be printed annually in the publications of the Institution.

52.—The publications of the Institution shall only be supplied to members, and no duplicate copies of any portion of the publications shall be issued to any member or Federated Institute unless by order of the Council.

53.—The annual volume or volumes of the publications may be sold, in the complete form only, at such prices as may be determined from time to time by

the Council:—To non-members for not less than £3; and to members who are desirous of completing their sets of the publications, for not less than 20s.

54.—The Institution, as a body, is not responsible for the statements and opinions advanced in the papers which may be read or in the discussions which may take place at the meetings of the Institution or of the Federated Institutes.

VIII.—Medals and other Rewards.

55.—The Council, if they think fit in any year, may award a sum not exceeding sixty pounds, in the form of medals or other rewards, to the author or authors of papers published in the *Transactions*.

IX.—Property.

56.—The capital fund shall consist of such amounts as shall from time to time be determined by resolution of the Council.

57.—The Institution may make use of the following receipts for its expenses:—

(a) The interest of its accumulated capital fund;
(b) The annual subscriptions; and
(c) Receipts of all other descriptions.

58.—The Institution may form a collection of papers, books and models.

59.—Societies or members who may have ceased their connexion with the Institution shall have no claim to participate in any of its properties.

60.—All donations to the Institution shall be acknowledged in the annual report of the Council.

X.—Alteration of Bye-laws.

61.—No alteration shall be made in the bye-laws of the Institution, except at a special meeting of the Council called for that purpose, and the particulars of every such alteration shall be announced at their previous meeting and inserted in the minutes, and shall be sent to all members of Council at least fourteen days previous to such special meeting, and such special meeting shall have power to adopt any modification of such proposed alteration of the byelaws, subject to confirmation by the next ensuing Council meeting.

THE INSTITUTION OF MINING ENGINEERS.

SUBJECTS FOR PAPERS.

The Council of The Institution of Mining Engineers invite original communications on the subjects in the following list, together with other questions of interest to mining and metallurgical engineers.

Assaying.
Boiler explosions.
Bore-holes and prospecting.
Boring against water and gases.
Brickmaking by machinery.
Brine-pumping.
Canals, inland navigation, and the canalization of rivers.
Coal-getting by machinery.
Coal-washing machinery.
Coke manufacture and recovery of bye-products.
Colliery leases, and limited liability companies.
Compound winding-engines.
Compressed-air as a motive-power.
Corrosive action of mine-water on pumps, etc.
Descriptions of coal-fields.
Diamond-mining.
Distillation of oil-shales.
Drift and placer-mining.
Duration of coal-fields of the world.
Electric mining lamps.
Electricity and its applications in mines.
Electro-metallurgy of copper, etc.
Engine-counters and speed-recorders.
Explosions in mines.
Explosives used in mines.
Faults and veins.
Fuels and fluxes.
Gas-producers, and gaseous fuel and illuminants.
Gas-, oil-, and petroleum-engines.
Geology and mineralogy.
Gold-recovery plant and processes.
Graphite: its mining and treatment.
Haulage in mines.
Industrial assurance.
Inspection of mines.
Laws of mining and other concessions.
Lead-smelting.
Light railways.
Lubricating value of grease and oils.
Lubrication of trams and tubs.
Maintenance of canals in mining districts.
Manufacture of fuel-briquettes.
Mechanical preparation of ores and minerals.
Mechanical ventilation of mines, and efficiency of the various classes of ventilators.
Metallurgy of gold, silver, iron, copper, lead, etc.
Mining and uses of arsenic, asbestos. bauxite, mercury, etc.
Natural gas, conveyance and uses.
Occurrence of mineral ores, etc.
Ore-sampling machines.
Petroleum-deposits.
Preservation of timber.
Prevention of over-winding.
Pumping machinery.
Pyrometers and their application.
Quarries and methods of quarrying.
Rock-drills.
Safety-lamps.
Salt-mining, etc.
Screening, sorting and cleaning of coal.
Shipping and discharge of coal-cargoes.
Sinking, coffering and tubbing of shafts.
Sleepers of cast-iron, steel, and wood.
Spontaneous ignition of coal and coal-seams.
Stamp-milling.
Steam-condensation arrangements.
Steam-power plants.
Submarine coal-mining.
Subsidences caused by mining-operations.
Surface-arrangements at mines.
Surveying.
Tin-mining.
Transport on roads.
Tunnelling, methods and appliances.
Utilization of dust and refuse coal.
Utilization of sulphureous gases resulting from metallurgical processes.
Ventilation of coal-cargoes.
Water as a motive-power in mines.
Water-tube boilers.
Watering coal-dust.
Water-incrustations in boilers, pumps, etc.
Winding arrangements at mines.
Winning and working of mines at great depths.

For selected papers, the Council may award prizes. In making awards, no distinction is made between communications received from members of the Institution or others.

TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
AUGUST 3RD, 1907.

MR. J. H. MERIVALE, PRESIDENT, IN THE CHAIR.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on July 20th and that day, and of the Council of The Institution of Mining Engineers.

ELECTION OF OFFICERS, 1907-1908.

The CHAIRMAN (Mr. J. H. Merivale) appointed Messrs. C. A. Crofton, A. M. Hedley, N. B. Ridley, John Simpson, J. Southern and W. B. Wilson, jun., as scrutineers of the balloting-papers for the election of officers for the year 1907-1908.

The SCRUTINEERS afterwards reported the result of the ballot, as follows:—

PRESIDENT:
Mr. J. H. MERIVALE.

VICE-PRESIDENTS:

Mr. R. D. BAIN.	Mr. F. COULSON.	Mr. H. PALMER.
Mr. W. C. BLACKETT.	Mr. T. E. FORSTER.	Mr. J. SIMPSON.

COUNCILLORS:

Mr. R. S. Anderson.	Mr. T. E. Jobling.	Mr. J. H. Nicholson.
Mr. J. B. Atkinson.	Mr. J. P. Kirkup.	Hon. C. A. Parsons.
Mr. C. S. Carnes.	Mr. P. Kirkup.	Mr. F. R. Simpson.
Mr. B. Dodd.	Mr. H. Lawrence.	Mr. C. H. Steavenson.
Mr. S. Hare.	Mr. C. C. Leach.	Mr. S. Tate.
Mr. A. M. Hedley.	Mr. A. D. Nicholson.	Mr. R. L. Weeks.

Mr. C. S. Carnes moved a vote of thanks to the Scrutineers for their services.

Mr. J. G. Weeks seconded the resolution, which was cordially adopted.

Mr. E. S. Wood moved a vote of thanks to the President. Vice-Presidents, Councillors and Officers for their services during the past year.

Mr. W. B. Wilson seconded the motion, which was heartily adopted.

Mr. C. H. Merivale moved a vote of thanks to the representatives of this Institute on the Council of The Institution of Mining Engineers for their services during the past year.

Mr. N. B. Ridley seconded the proposal, which was cordially adopted.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1906-1907.

The Institute has sustained great losses through the death of Mr. John Daglish, a past-president of the Institute, and one of its original members; and through the death of Mr. William Fairbairn Hall, a member since 1858, and a vice-president, 1892-1896.

The following table shows the variation of the membership during recent years:—

Year ending August 1st.	1901.	1904.	1907.
Honorary members	28	26	21
Members	880	955	903
Associate members	122	115	108
Associates	116	163	194
Students	57	66	47
Subscribers	23	25	34
Totals	1.226	1,350	1,307

A Committee, consisting of Messrs. T. E. Forster, George May, J. H. Merivale, J. G. Weeks and the Secretary (Mr. M. Walton Brown), appointed to enquire into and report upon the decrease of the attendance at the Colliery Engineers' Classes, reported that the apparent decrease in the number of students in recent years arose from the poor quality of those attending in early years, and they were of opinion that the present students were fully capable of taking advantage of the lectures. Certain alterations in the syllabus of lectures, suggested by the Committee, were agreed to by the authorities of Armstrong College.

Mr. J. Parke Channing was appointed to represent the Institute at the opening of the United Engineering Societies' Building, New York City, in April, 1907. Mr. R. H. Prior-Wandesforde represented the Institute at the Conference of the Royal Sanitary Institute, held at Dublin, in June, 1907. The Rev. G. M. Capell represented the Institute at the Conference of the Corresponding Societies of the British Association for the Advancement of Science, held in Leicester, commencing on July 31st, 1907. The Geological Society of London will celebrate the centenary of their existence in September, 1907, and Prof. G. A. L. Lebour has been appointed to represent the Institute thereat, and will present an address.

Mr. J. H. Merivale has given evidence, as the representative of the Institute, before the Departmental Committee on the Miners' Eight Hours' Day.

G. C. Greenwell silver medals have been awarded to Mr. W. E. Garforth for his paper upon "A New Apparatus for Rescue-work in Mines,"* and to Mr. G. A. Meyer for his paper upon "Rescue-apparatus and the Experiences gained therewith at the Courrières Collieries by the German Rescue-party;"† and a bronze medal has been awarded to Mr. S. F. Walker for his

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 625.

† *Ibid.*, 1906, vol. xxxi., page 575.

papers upon "Earth in Collieries, with reference to the 'Special Rules for the Installation and Use of Electricity'"* and "The Capacity-current and its Effect on Leakage-indications on Three-phase Electrical Power-service."†

Prizes for books have been awarded to the writers of the following papers, communicated to the members during the year 1905-1906:—

"Improved Dampers for Coke-oven Flues." By Mr. William Archer, M.I.M.E.

"A Mechanical Coal-cutter in Queensland." By Mr. William Fryar.

"The Great Planes of Strain in the Absolute Roof of Mines." By Mr. Henry Wallace Gregory Halbaum, M.I.M.E.

"Corundum in Ontario, Canada: Its Occurrence, Working, Milling, Concentration and Preparation for the Market as an Abrasive." By Mr. David Gillespie Kerr, M.I.M.E.

"The Alumino-thermic Welding Process, and its Application to General Engineering." By Mr J. Stewart MacGregor.

"The Unwatering of the Achddu Colliery, with a Description of the Riedler Express Pump." By Mr. John Morris, M.I.M.E.

"Undersea Extensions at the Whitehaven Collieries, and the Driving of the Ladysmith Drift." By Mr. John Shanks, M.I.M.E.

"The Barton and Forcett Limestone-quarries." By Mr. Thomas Teasdale, M.I.M.E.

"Determination of the Specific Electrical Resistance of Coal, Ores, etc." By Mr. G. C. Wood.

At the recommendation of the Committee appointed to enquire into the treatment of coal-dust in collieries, the Council have made a maintenance-grant of £50 towards the cost of conducting further experiments on the inflammability of mixtures of coal-dust and air, together with £25 for apparatus, to Mr. Henry Widdas of Armstrong College. Dr. P. P. Bedson and Mr. Henry Widdas have read a paper, illustrated with numerous "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air."

Members of the American Institute of Mining Engineers visited Newcastle-upon-Tyne on August 1st and 2nd, 1906, and visits to collieries, works, Bamburgh and Alnwick Castles and the Roman Wall were arranged for their entertainment. The thanks of the American Institute of Mining Engineers have been received for the courtesy shown to its members.

Excursion meetings were held at Bowburn colliery on September 10th, 1906; at Axwell Park colliery on December 5th, 1906; and at Wearmouth colliery on June 6th, 1907.

* *Trans. Inst. M. E.*, 1905, vol. xxx., page 404.

† *Ibid.*, 1906, vol. xxxi., page 526.

The thanks of the Institute have been sent to the owners of collieries, works, etc., visited during the year.

The papers printed in the *Transactions* during the year are as follows:—

"Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air." By Prof. P. Phillips Bedson, Hon. M.I.M.E., and Mr. Henry Widdas, M.I.M.E.

"Memoir of the late John Daglish." By Mr. M. Walton Brown, M.I.M.E.

"An Appliance for Automatically Stopping and Restarting Mine-wagons." By Prof. William Galloway, M.I.M.E.

"Ferro-concrete and its Applications." By Mr. T. J. Gueritte.

"Treatment of Dust in Mines, Aboveground and Belowground." By Mr. Richard Harle, M.I.M.E.

"Sliding-trough Conveyors." By Mr. M. Malplat.

"The Valuation of Mineral Properties." By Mr. Thomas Aloysius O'Donahue, M.I.M.E.

"Liquid Air and its Use in Rescue-apparatus." By Mr. Otto Simonis.

"Deposits in a Pit-fall at Tanfield Lea, Tantobie, County Durham." By Dr. J. A. Smythe.

"Bowburn Winning." By Mr. Addison Langhorne Steavenson, M.I.M.E.

"Electro-barograph for Mines." By Mr. B. H. Thwaite.

"Sinking through Magnesian Limestone and Yellow Sand by the Freezing-process at Dawdon Colliery, near Seaham Harbour, County Durham." By Mr. Ernest Seymour Wood, M.I.M.E.

The Council are pleased to report that the North-eastern Railway Company have granted reduced railway-fares to members attending general or excursion meetings of the Institute; and they trust that this concession will lead to an increased attendance.

The Institution of Mining Engineers has now entered upon its nineteenth year, and the members are to be congratulated upon its continued success, and the increasing membership of the associated institutions. Meetings were held in Hanley in September, 1906, and in London in June, 1907.

Mr. Thomas Douglas, referring to the decrease in the attendance at the colliery-engineers' classes at Armstrong College, said that it was very desirable that a large attendance should be secured.

Mr. M. Walton Brown said that it was important that colliery managers should see that those who attended these classes possessed such elementary knowledge, especially in mathematics, as would render the lectures advantageous to them.

The PRESIDENT (Mr. J. H. Merivale) moved the adoption of the Annual Report of the Council.

Mr. J. B. SIMPSON seconded the motion, which was adopted.

The Report of the Finance Committee was read as follows:—

ANNUAL REPORT OF THE FINANCE COMMITTEE.

The Finance Committee submit herewith a statement of accounts for the twelve months ending June 30th, 1907, duly audited.

The total receipts were £2,978 0s. 3d. Of this amount, £49 19s. was paid as subscriptions in advance, leaving £2,928 1s. 3d. as the ordinary income of the year, compared with £2,838 2s. 3d. in the previous year. The amount received for ordinary current-year subscriptions was £2,264 17s. and arrears £318 9s., as against £2,249 1s. and £287 16s. respectively in the year 1905-1906. *Transactions* sold realized £19 3s. 9d., as compared with £44 4s. 3d. in the earlier period; the sum received for interest on investments was £325 11s. 6d., the amount in the former year being £317 10s.

The expenditure was £2,622 13s. 3d., that for the previous year being £2,544 10s. 10d. The increase was due to expenditure in connection with the visit of the American Institute of Mining Engineers; the contribution of £75 towards the cost of experiments on coal-dust conducted at Armstrong College; and expenses incurred in the preparation of the Library catalogue. Increases are also shown in the charges for salaries and wages, heating and lighting, postages, etc., while there is a considerable decrease in the amount spent on the Wood Memorial Hall and also for printing and stationery, the latter in consequence of certain liabilities remaining unpaid at the close of the year, but carried forward and included in the balance-sheet.

The figures given above show that the income exceeded the expenditure by £355 7s., and adding to this the balance of £896 19s. 6d., a total balance of £1,252 6s. 6d. remains to the credit of the Institute. Of this amount, £499 17s. 6d. has been invested in the purchase of stock of the Newcastle and Gateshead Water Company, leaving the sum of £752 9s. to carry forward.

The names of 32 persons have been struck off the membership list in consequence of non-payment of subscriptions. The amount of subscriptions written off was £176 3s., of which £96 18s. was for sums due for the year 1906-1907, and £79 5s. for arrears. It is probable that a considerable proportion of these amounts will be recovered and credited in future years. Of the amounts previously written off, £68 16s. was recovered during the past year.

JOHN H. MERIVALE, *President.*

August 3rd, 1907.

The PRESIDENT (Mr. J. H. Merivale), in moving the adoption of the Annual Report of the Finance Committee, remarked that the financial position of the Institute was very satisfactory.

Mr. J. G. WEEKS seconded the resolution, which was adopted.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1907-1908.

The PRESIDENT (Mr. J. H. Merivale) moved, and Mr. Thomas Douglas seconded, a resolution that the following gentlemen be elected as the representatives of the Institute on the Council of The Institution of Mining Engineers for the year 1907-1908:—

Mr. W. ARMSTRONG.	Mr. J. W. FRYAR.	Mr. J. H. MERIVALE.
Mr. B. H. BROUGH.	Mr. W. GALLOWAY.	Mr. C. A. MOREING.
Mr. C. S. CARNES.	Mr. T. Y. GREENER.	Mr. J. J. PREST.
Mr. A. G. CHARLETON.	Mr. S. HARE.	Mr. R. F. SPENCE.
Mr. F. COULSON.	Mr. A. M. HEDLEY.	Mr. C. H. STEAVENSON.
Mr. B. DODD.	Mr. P. KIRKUP.	Mr. J. G. WEEKS.
Mr. T. DOUGLAS.	Mr. C. C. LEACH.	Mr. R. L. WEEKS.
Mr. J. H. B. FORSTER.	Mr. J. McMURTRIE.	Mr. A. N. L. WOOD.
	Mr. G. MAY.	

The resolution was agreed to.

DR. THE TREASURER IN ACCOUNT WITH THE NORTH OF ENGLAND
FOR THE YEAR ENDING

		£ s. d.	£ s. d.
June 30th, 1906.			
To balance of account at bankers		840 11 3	
„ „ in Treasurer's hands		53 9 9	
„ outstanding accounts due from authors for excerpts		2 18 6	
			896 19 6
June 30th, 1907.			
To dividend of 7½ per cent. on 179 shares of £20 each in the Institute and Coal-trade Chambers Company, Limited, for the year ending June 30th, 1907 ...		268 10 0	
„ interest on mortgage of £1,400 with the Institute and Coal-trade Chambers Company, Limited		49 0 0	
„ dividend on £340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company		8 1 6	
			325 11 6
To sales of *Transactions*			19 3 9
To SUBSCRIPTIONS FOR 1906-1907 AS FOLLOWS:—			
762 members ... ... @ £2 2s.		1,600 4 0	
85 associate members ... ... @ £2 2s.		178 10 0	
159 associates ... ... @ £1 5s.		198 15 0	
46 students ... ... @ £1 5s.		57 10 0	
24 new members ... ... @ £2 2s.		50 8 0	
5 new members, not yet elected ... @ £2 2s.		10 10 0	
7 new associate members ... ... @ £2 2s.		14 14 0	
1 new associate member, not yet elected @ £2 2s.		2 2 0	
11 new associates ... ... @ £1 5s.		13 15 0	
1 new associate, not yet elected ... @ £1 5s.		1 5 0	
9 new students ... ... @ £1 5s.		11 5 0	
		2,138 18 0	
33 subscribing firms	£113 8 0		
1 new subscribing firm	2 2 0		
1 new subscribing firm, not yet elected	2 2 0		
		117 12 0	
		2,256 10 0	
1 associate member, paid life-composition	31 0 0		
1 new member, paid life-composition	23 2 0		
		54 2 0	
		2,310 12 0	
Less, subscriptions for current year paid in advance at end of last year		45 15 0	
		2,264 17 0	
Add, arrears received		318 9 0	
		2,583 6 0	
Add, subscriptions paid in advance during current year		49 19 0	
			2,633 5 0
			£3,874 19 9

INSTITUTE OF MINING AND MECHANICAL ENGINEERS — CR.
JUNE 30TH, 1907.

June 30th, 1907.		£ s. d.	£ s. d.
By *Annual Report* ...		45 5 0	
" banker's charges ...		22 1 6	
" circulars and advance copies of papers ...		64 10 8	
" cleaning Wood Memorial Hall, offices, etc. ...		30 1 11	
" electric light ...		28 7 0	
" expenses of meetings ...		95 3 3	
" fuel ...		23 0 9	
" furniture and repairs ...		27 0 10	
" incidental expenses ...		5 6 1	
" insurance ...		13 17 9	
" investments ...		499 17 6	
" library: binding ...	£31 6 9		
" " books ...	26 9 9		
" " catalogue ...	23 0 0		
		80 16 6	
" petty cash ...		2 9 4	
" postages: circulars ...	£42 3 6		
" " correspondence ...	20 15 2		
" " publications ...	23 8 8		
		86 7 4	
" panels and portraits of Presidents ...		48 17 0	
" prizes for papers ...		24 3 0	
" rates and taxes ...		6 3 6	
" rent of offices ...		24 9 8	
" *Report of the Committee upon Mechanical Coal-cutting*		2 12 6	
" reporting of general meetings ...		12 12 0	
" salaries, wages, auditing, etc. ...		531 6 6	
" stationery, etc. ...		26 15 5	
" telephone rent ...		1 5 0	
" travelling expenses ...		2 15 3	
" Treatment of Coal-dust Committee ...		88 6 0	
" water rate ...		3 17 8	
			1,797 8 6
By The Institution of Mining Engineers ...		1,326 17 4	
Less, amounts paid by authors for excerpts ...		1 15 1	
			1,325 2 3
			3,122 10 9
By balance of account at bankers ...		711 4 7	
" " in Treasurer's hands ...		38 5 11	
" outstanding accounts due from authors for excerpts		2 18 6	
			752 9 0
			£3,874 19 9

Dr. The Treasurer of The North of England Institute of Mining

	£ s. d.	£ s. d.	£ s. d.
To 931 members, 51 of whom have paid life-compositions.			
880			
2 not included in printed list.			
882 @ £2 2s.		1,852 4 0	
To 114 associate members. 8 of whom have paid life-compositions			
106			
1 paid life-composition.	31 0 0		
105 @ £2 2s.	220 10 0		
		251 10 0	
To 190 associates, 1 of whom has paid a life-composition.			
189 @ £1 5s.		236 5 0	
To 56 students, 1 paid as a member.			
55 @ £1 5s.		68 15 0	
To 33 subscribing firms		113 8 0	
			2,522 2 0
To 24 new members @ £2 2s.	50 8 0		
1 new member, paid a life-composition ...	23 2 0		
5 new members, not yet elected @ £2 2s.	10 10 0		
30		84 0 0	
To 7 new associate members @ £2 2s.	14 14 0		
1 new associate member, not yet elected	2 2 0		
8		16 16 0	
To 11 new associates @ £1 5s.	13 15 0		
1 new associate, not yet elected @ £1 5s.	1 5 0		
12		15 0 0	
To 9 new students @ £1 5s.		11 5 0	
To 1 new subscribing firm	2 2 0		
1 new subscribing firm, not yet elected ...	2 2 0		
		4 4 0	
2			131 5 0
To arrears, as per balance sheet, 1905-1906		419 15 0	
Add, arrears considered irrecoverable, but since paid ...		68 16 0	
			488 11 0
			3,141 18 0
To subscriptions paid in advance			49 19 0
			£3,191 17 0

AND MECHANICAL ENGINEERS IN ACCOUNT WITH SUBSCRIPTIONS, 1906-1907. CR.

			Paid. £ s. d.	Unpaid. £ s. d.	Struck off List. £ s. d.
By 762	members, paid	@ £2 2s.	1,600 4 0	......	......
89	" unpaid ...	@ £2 2s.	......	186 18 0	......
5	" excused payment	@ £2 2s.	......	......	10 10 0
5	" dead	@ £2 2s.	......	......	10 10 0
21	" struck off list	@ £2 2s.	......	......	44 2 0
882					
By 85	associate members, paid	@ £2 2s.	178 10 0	......	......
1	" " paid a life-composition		31 0 0	......	......
12	" " unpaid	@ £2 2s.	......	25 4 0	......
2	" " excused	@ £2 2s.	......	......	4 4 0
6	" " struck off list		......	......	12 12 0
106					
By 159	associates, paid	@ £1 5s.	198 15 0	......	......
22	" unpaid ...	@ £1 5s.	......	27 10 0	......
8	" struck off list	@ £1 5s.	......	......	10 0 0
189					
By 46	students, paid	@ £1 5s.	57 10 0	......	......
5	" unpaid ...	@ £1 5s.	......	6 5 0	......
1	" excused payment	@ £1 5s.	......	......	1 5 0
3	" struck off list...	@ £1 5s.	......	......	3 15 0
55					
By 33	subscribing firms, paid		113 8 0	......	......
By 24	new members, paid ...	@ £2 2s.	50 8 0	......	......
1	" " paid a life-composition		23 2 0	......	......
5	" " not yet elected	@ £2 2s.	10 10 0	......	......
30					
By 7	new associate members, paid	@ £2 2s.	14 14 0	......	......
1	" " not yet elected	@ £2 2s.	2 2 0	......	......
8					
By 11	new associates, paid ...	@ £1 5s.	13 15 0	......	......
1	" " not yet elected	@ £1 5s.	1 5 0	......	......
12					
By 9	new students, paid ...	@ £1 5s.	11 5 0	......	......
By 2	new subscribing firms, paid	@ £2 2s.	4 4 0	......	......
			2,310 12 0	245 17 0	96 18 0
By arrears	... ...		318 9 0	90 17 0	79 5 0
			2,629 1 0		
By subscriptions paid in advance	... ...		49 19 0	......	......
			2,679 0 0	336 14 0	176 3 0
					336 14 0
					2.679 0 0
					£3,191 17 0

The North of England Institute of Mining and Mechanical Engineers: General Statement, June 30th, 1907.

Liabilities.

	£ s. d.	£ s. d.
Subscriptions paid in advance during the current year		54 3 0
The Institution of Mining Engineers ...		49 18 2
The George Clementson Greenwell prize fund	100 0 0	
Less, paid for medals	67 8 4	
		32 11 8
Printing, etc.		80 0 0
Capital		12,345 1 11
		£12,561 14 9

Assets.

	£ s. d.	£ s. d.
Balance of account at bankers	711 4 7	
„ in Treasurer's hands	38 5 11	
Outstanding accounts due from authors for excerpts	2 18 6	
		752 9 0
Arrears of subscriptions		336 14 0
179 shares in the Institute and Coal-trade Chambers Company, Limited (at cost) ...	4,100 0 0	
Institute and Coal-trade Chambers Company, Limited (mortgage)	1,400 0 0	
£340 consolidated 5 per cent. preference stock of the Newcastle and Gateshead Water Company (at cost)	499 17 6	
		5,999 17 6
(Of the above amount, £1,640 2s. is due to life-subscriptions account.)		
Value of *Transactions* and other publications, as per stock account	322 14 3	
Books, pictures, maps, furniture and fittings	5,150 0 0	
		5,472 14 3
		£12,561 14 9

We, having examined the above account with the books, vouchers and securities relating thereto, certify that, in our opinion, it is correct. We have accepted the assets, books, pictures, maps, etc., and *Transactions* and other publications as valued by your officials.

JOHN G. BENSON AND SONS,
CHARTERED ACCOUNTANTS.

Newcastle-upon-Tyne,
August 3rd, 1907.

G. C. GREENWELL MEDALS.

The PRESIDENT (Mr. J. H. Merivale) presented the Greenwell medals, which had been awarded by the Council to Mr. W. E. Garforth for his paper on "A New Apparatus for Rescue-work in Mines;"* to Mr. G. A. Meyer for his paper on "Rescue-apparatus and the Experiences gained therewith at the Courrières Collieries by the German Rescue-party;"† and to Mr. S. F. Walker for his papers upon "Earth in Collieries, with Reference to the 'Special Rules for the Installation and Use of Electricity,'"‡ and "The Capacity-current and its Effect on Leakage-indications on Three-phase Electrical Power-service."§

Mr. W. E. GARFORTH wrote that he was pleased to receive the G. C. Greenwell silver medal awarded to him for his paper on "A New Apparatus for Rescue-work in Mines." He thanked the Council for their kindness, which he much appreciated. If he could, at any time, afford assistance to the Council, either with the apparatus or by giving information about the rescue-gallery, any experience that he had gained was quite at their disposal.

Mr. G. A. MEYER wrote that he esteemed it a great honour to be placed in such an enviable connection with the name of one of the founders of the Institute by the kind resolution of the Council. In receiving this award, he remembered the time, just twenty years ago, when, as a mining student, he made his first studies of British mine-engineering in the Royal Mining, Engineering and Industrial Exhibition at Newcastle-upon-Tyne, in the mines of the neighbourhood, and in the library of the Wood Memorial Hall. He had remained in close touch with British mine-engineering since that time, and he had profited and widened his own knowledge by this valuable connection. He was proud to feel that this connection was strengthened by the kindness of the Council of The North of England Institute of Mining and Mechanical Engineers in presenting the G. C. Greenwell silver medal to him, and he expressed his heartiest thanks for the honour which the Council had been good enough to confer on him.

Mr. SYDNEY F. WALKER thanked the Council for the honour which they had conferred upon him by awarding him the G. C.

* *Trans. Inst. M. E.*, 1906, vol. xxxi., page 625.

† *Ibid.*, 1906, vol. xxxi., page 575. ‡ *Ibid.*, 1905, vol. xxx., page 404.

§ *Ibid.*, 1906, vol. xxxi., page 526.

Greenwell bronze medal for his papers. It was certainly pleasant to know that one's work was appreciated, and he had always felt that his writings were especially appreciated in the North of England.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. FRITZ BAARE, General Manager of Steel-works, Bochum, Westphalia, Germany.

Mr. ALBURTO BEMENT, Mechanical Engineer, American Trust Building, Chicago, Illinois, U.S.A.

Mr. RALPH RICHARDSON BROWN, Colliery Manager, Pekin Syndicate, Honan, North China.

Mr. JAMES CHALMERS, Civil Engineer, Obras do Porto do Rio de Janeiro, Caixa 711, Rio de Janeiro, Brazil, South America.

Mr. BERENT CONRAD GULLACHSEN, Mining Engineer, Hotel Norge, Bergen, Norway.

Mr. FREDERICK WILLIAM HYLTON, Mining Engineer, Ryhope Colliery, Sunderland.

Mr. REGINALD CHARLES MORTON, Electrical Engineer, 23, Lovaine Crescent, Newcastle-upon-Tyne.

Mr. ARTHUR HERBERT SHEEPSHANKS PAGE, Under-manager, Etherley, Bishop Auckland.

Mr. CHARLES EDMUND RAY, Mining Engineer, Whinfield, near Ulverston.

Mr. FRED RICHARDS, Mine-manager and Assayer, Blaenau, Compton Road, Canonbury, London, N.

Mr. JEAN ADOLF ROELOFSEN, Coke-oven Manager and Chemical Engineer, Post Office Buildings, Middlesbrough.

Mr. JOSEPH SEYMOUR ROWE, Colliery Manager, Metropolitan Colliery, Helensburgh, New South Wales, Australia.

ASSOCIATE MEMBER—

Mr. PERCY COLLINSON LEAKE, Thomas Terrace, Blaydon-upon-Tyne, S.O., County Durham.

ASSOCIATES—

Mr. DAVID MILLNE, Coal-miner, 1, Burdon Street, Bedlington, S.O., Northumberland.

Mr. HENRY HERBERT NICHOLS, Under-manager, Kibblesworth, Gateshead-upon-Tyne.

Mr. ROBERT RATCLIFFE, Deputy, Beamish, S.O., County Durham.

STUDENTS—

Mr. HENRY EDMUND BLACKBURNE DANIELL, Mining Student, 8, Ashfield Terrace, Ryton, S.O., County Durham.

Mr. ROBERT CLARK THOMAS, Mining Student, Houghton Colliery, Houghton-le-Spring, S.O., County Durham.

Mr. J. H. MERIVALE delivered the following "Presidential Address":—

PRESIDENTIAL ADDRESS.

By J. H. MERIVALE.

I thank you for having elected me for a second year of office as your President; and also for the support that you have given to me at these meetings by reading and discussing the papers. Many of these papers are of much interest, and a list of them has been laid before you in the annual report of the Council.

The only matter of importance that has occurred during my first year of office has been the placing upon the walls of this theatre of many of the portraits of past-presidents of the Institute. This it was decided by the Council should be done some years ago, and the panels to hold the portraits were put in place. Twelve of these panels have now been filled; and I have reason to believe that the rest of the portraits will be presented and hung before the termination of my second year of office. It is an interesting record, and one which will become more and more interesting as years roll on.

"The proper study of mankind is Man"; and, whilst considering what would be a suitable subject upon which to address you, it was forced upon me that this very important factor in the success of our industry, Man, had been somewhat neglected.

Some of my predecessors, who had made some one branch of the science of mining their own, had, out of the fullness of their knowledge, given us much interesting and valuable information upon it, whilst others had given us a luminous résumé of the advancements recently made in mining at the time of their taking office. But no one appeared to have taken Man as the subject of his discourse.

Great strides have been made in the introduction of new and improved machinery since the birth of this Institute in 1852. Have there also been improvements in the men required to guide these machines, without whom the full benefit of their introduction cannot be obtained?

Important as is the mechanical side of our profession, the human side is, in my opinion, of still greater importance. The best tools will be of no avail, without intelligent workmen trained to use them, and highly educated managers capable of directing these workmen and of designing new and improved machinery fit to cope with fresh difficulties arising from the changing conditions of our industry. The importance of the character of "the man behind the gun" is proverbial, and the character of the man at the machine is equally important.

I had proposed to consider this subject, Man—both the engineer and the workman—under various heads, such as amusements, capital and labour, efficiency, health, thrift, etc. But I soon found that the subject was far too vast to be compressed within the limits of a Presidential address. I have therefore confined myself to the workman only, and considered the changes that have occurred during the last 50 or 60 years in his amusements and in his relations with capital.

His Amusements.*

The amusements of our workmen may appear rather a frivolous subject to be included in a Presidential address. But, with an eight hours' day almost an accomplished fact, one of the avowed objects of which is to give them more leisure, it is evident that the nation considers the question of recreation a matter of some importance; and it appears to me that the question of how the miner will use this spare time is of very practical interest to the coal-trade.

It is a task of no little difficulty to look back over half a century, and recollect the principal methods of amusement which found favour in Durham and Northumberland in those days. The sporting centre of the north was then, as now, Newcastle, and the athletic events which brought the sturdy pitman into the city at that time may be taken as a reflection of the contests of less importance in his own village, in which he took, or had taken in younger days, a personal share. For it was the best of sport that was visible in Newcastle, the minor lights staying to wrestle on the village-green or to quoit upon a space of ground situated in convenient proximity to the village

* I have to thank Mr. J. F. Petrie for a great deal of information upon this subject, and take this opportunity of doing so.

hostelry; while those of greater skill came to "the toon" to try conclusions for championships, to win or lose large stakes for themselves and more momentous wagers for their admiring friends. Horse-racing was the sport *par excellence*, though hardly, by reason of its infrequency, to be called the most important. Bowling, not the peaceful pastime of the quiet lawn, but the more strenuous game in which stalwarts (stripped to what the local phrase designates "linings") hurl heavy "potshares," varying from 5 to 50 ounces in weight, was distinctly one of the most popular pastimes of half a century ago. From many points of view it is to be admired as a form of sport. Simple though its rules may be, it requires no small skill; for a man who desires to excel must be able to throw his bowl not merely over a long distance, but with an accuracy which will assure its alighting upon a favourable spot and avoiding rough ground which might retard its progress. It is a vigorous exercise in itself, and it has the additional advantage of taking its devotees away from surroundings which offer many temptations to the man with a light heart and a full pocket. The town moor had always been the main centre of bowling, but many famous matches were brought off on the sands at Newbiggin, Shields, Blyth and Castle Eden; and there were not a few inland courses where the pitmen gathered to throw their bowls, and to "back" their fancy with a perhaps more than judicious portion of their hard-earned pay. It is worthy of remark that bowling, which had almost died out in the intervening years, has suddenly seen a great revival; and I am told that it is not at all uncommon for five or six thousand spectators to assemble on Newcastle moor when two recognized experts are trying conclusions for a substantial stake.

Natural causes had much to do with the immense vogue of rowing in the fifties amongst the working-class population. The keelmen had in their ranks many keen oarsmen, and the banks of the river Tyne afforded innumerable points of vantage for watching both the practices and the contests themselves. Thus, with circumstances providing many performers and supplying their audiences with every convenience, it is not difficult to see why rowing should have attained a prominent place in north-country sports. It was not only on Tyneside that rowing had

its hold. The other local rivers all contributed their quota to the men who were the outstanding figures of the fifties, when the contests decided on the Tyne occupied the attention of all the world. Clasper, Chambers and Winship were the prominent personalities then, and they were followed by many others of little less renown.

No sport of all those that appealed to the affections of north-countrymen has fallen upon more evil days than this. There is now no professional rowing worth the name, and the time-honoured Christmas handicap is, I believe, only kept alive with difficulty and arouses an infinitesimal interest. There are many causes for the change. It is charitable to place first amongst them the increase of traffic on the river and the building-up of its banks. On the other hand, the symptoms of decay undoubtedly manifested themselves before either of these things had affected the sport. And the reason is equally obvious and infinitely more unpleasant.

The sport died a natural death. A matter to me of great regret, as I have always taken a great interest in rowing; and many of the pleasantest evenings of my residence in Newcastle in the early seventies were spent upon the Tyne, not only as a competitor in some of the minor contests, in which I was not unsuccessful, but in the encouragement of this sport at the Durham University colleges.

It is not likely nowadays to be revived, and its memory only remains with the older generation as one of the great features of the recreation of the toilers of the north in the "good old days."

Horse-racing has always been popular, and meetings have been held in several centres in the mining districts; such as Amble, Blaydon, Boldon flats, Durham, and Houghton-le-Spring for very many years. Newcastle races, however, when they were held upon the town moor, formed the biggest sporting event of the year. Nowadays they are not so intrinsically important as races. They serve for the mass of the population as an excuse for the annual holiday, and the gathering at Gosforth Park is only an incident in a general exodus. But in those days the races were the centre of attraction, and the town moor was the Mecca of every northern pilgrim. They were more robust days, and the concourse might have been rougher, perhaps less decorous, but there

is no denying that the spirit of enjoyment was more general and keener. The local feeling, too, was greater. The miners were—and are still—to a greater extent than any other body of workers averse to patronizing a sport which they could not see. They liked to see the horses that they had backed run for their money, and they were lifted into ineffable realms of delight when a north-country horse brought the Northumberland Plate to a north-country owner—especially if its victory also enabled them to celebrate the holiday more lavishly. It was in 1852, "Stilton's year," the date of our foundation, that the Northumberland Plate was first run for straight out, and the system of heats abolished; and it was in that year that the actual period of racing was confined to three days only. The festival proper, however, lasted for the full week, and during that period the town was invaded from all the colliery districts. Temporary licenses granted to the publicans caused a town of canvas-tents to spring up, and the day-refectories became night-shelters for many of the enthusiasts who had arrived with the firm determination of "making a week of it"—a determination, it may be added, which was unfalteringly and completely fulfilled. Shows of all descriptions, neither better nor worse it may be believed than those which to-day accompany the Temperance Festival, added to the show of canvas and multitudes of carriages, from the four-in-hand of the peer to the pony-trap of the publican, stretched in long lines on either side of the course. Racing, indeed, whilst it lasted dwarfed all other sports; and only at such great centres as York and Doncaster, where the contests were carried out on public spaces, were like spectacles of wild excitement and whole-hearted gaiety to be witnessed. The interest in horse-racing fifty years ago was not, it is to be believed, the same kind of interest as it is to-day.

It was certainly the only sport to which the press devoted any attention, small and often contemptuous paragraphs sufficing to cover the quoiting, the whippet running, the pigeon flying, and the wrestling. The publication of the results, however, was neither so prompt nor so important as to-day, and was not intended for the edification of the working classes, keen as was the interest and heavy as was the wagering by workmen. At Newcastle and at minor race-meetings in this district it was, generally speaking, of a more intermittent character and confined

very largely to the meetings themselves. It was only with the increased facilities for travel provided by improved railway-communication and the contemporary improvement of the telegraphic services of the press that the custom has grown of wagering on horses that have never been and never will be seen by their backers; and that the shop-boy has come to hazard his half-crown with the same assurance as the "Jubilee Plunger" threw away his thousands.

Special mention also should be made of wrestling, which if it never was, as in Cumberland and Westmorland and in some portions of the Lancashire coal-field, the paramount pastime, at any rate absorbed a great deal of attention, and always found a not unimportant place in the local athletic gatherings. In Newcastle fifty years ago there existed a wrestling green, near the old shot-tower, where many of the northern champions were seen; but that has long since passed away, and the fine old sport does not occupy much of the time and training of the athletes of to-day. Possibly the causes which contributed to the decay of rowing had a little to do with the decline in wrestling, as they certainly are responsible for the lowly place that boxing now occupies in the popular esteem. It is a great pity, for a finer pastime than the old style of wrestling, combining the need for courage, skill, endurance and self-control it would pass the wit of man to devise. Of the minor sports, whippet racing, pigeon and sparrow shooting and pigeon flying show the least changes, for they have always had, as they have to-day, a considerable number of followers. Rabbit coursing, I am pleased to note, is less popular than it used to be. Running appears to be going out of favour; and trippet and quoit or buck-stick, a favourite game some forty years ago, has disappeared altogether. Cricket, elsewhere the king of summer games, has never strongly appealed to the miner, who likes something a little more exciting and more easily comprehensible. Bathing also has never been popular. Probably because we seldom have here, on the north-east coast, a spell of really hot weather.

To-day, football, unknown amongst the miners five-and-twenty years ago, is the game which holds the greatest sway, and, whether for good or for ill, the district between the Tweed and the

Tees has caught the infection in a very pronounced degree. As played at present, in spite of the professional element, the game is kept, I believe, above suspicion for the most part; but, as it has become one of the great instruments of gambling, it is hardly to be supposed that it will long remain free from the canker which killed the once equally popular sport of rowing.

One of the most interesting examples of the growth in popularity of a particular sport is to be found in rifle shooting. The rifle is the legitimate and direct successor of the bow and arrow, a weapon which for certain purposes, principally social, is not yet entirely obsolete. Archery, however, has never been very popular in the north country, although there was once a flourishing club in Newcastle, and it may be said to be a thing of the past up here. But, as Regent's Park bears annual witness, it still has its devotees in the south. Rifle shooting on the other hand has found continuous favour since the inception of the volunteer movement; but the perfection of the modern weapon and the wave of patriotism which swept over the country during the South African war gave it an immense impetus. It is a matter for congratulation that the movement in favour of rifle shooting should have proved to be of a permanent character and to be so popular at many of our collieries, for, even from the purely sporting point of view, it is a pastime which possesses infinite attractions. It demands a keen eye, a steady hand, and an abundance of nerve, and if any real proficiency is to be attained it needs also much time spent on the open-air ranges. These essentials of the marksman are not to be obtained without considerable self-sacrifice and self-control. Lord Roberts, who has done so many fine things for his country, deserves its gratitude for the unceasing efforts that he has made of recent years to arouse an interest in rifle shooting, and it is very largely owing to his exertions that the civilian movement has reached its present large proportions. Locally, the enthusiasm for this branch of sport has been fostered by the endeavours of *The Newcastle Chronicle,* which, after being amongst the first business houses to establish a rifle club for its workpeople, has offered each year a valuable silver cup and a substantial sum in prize money open to competition by all comers. Since its establishment, six years ago, the meeting at which the cup is shot for has grown in

importance, until now it is the second largest in the United Kingdom, the national meeting at Bisley alone exceeding it in size. Over five hundred marksmen, regulars, volunteers and civilians were seen at the range this year when the trophy was shot for, and there can be no doubt that the gathering has had a most stimulating effect upon the growth of the rifle movement.

Fifty years ago cock-fighting was a popular pastime, and great were the rivalries between the various strains of birds. The time when the sport was at its height was on the morning of race-days, and there were various cock-pits in Gallowgate, where the miners used to assemble in crowds to see the mains. Modern feeling, however, is altogether opposed to a game which, whether inhuman or not, is certainly as unedifying as it is exciting. It is prohibited by law, of course; but there are a good many things prohibited by law which have not altogether been driven out of existence by legislative interference, and from what I have heard, I believe that if one were "in the know" it would not be an impossible task to buy a pair of silver spurs to-day and to see them used. It is, indeed, only a few months since we read in the newspapers of a successful prosecution of men for participating in an organised cocking main and it is not to be supposed that this solitary conviction bears any due proportion to the number of contests which do not officially attract the notice of the police. Though there still is some cock-fighting it may, however, be taken that its extent is infinitesimal compared with that of half a century ago, and there will be found few people to lament its decline.

Instrumental music is, and has always been, very popular. There are but few collieries that have not a brass band, often a very good one: Hebburn for example. But choirs are almost, if not entirely, non-existent. I started vocal societies at two collieries, in Durham, early in the seventies, which flourished for a time and gave much pleasure to the members, both men and women, if to no one else. But so soon as I left the neighbourhood, they ceased to exist. The reason I believe to be climatic; but space will not permit of my going into this question.

Golf and tennis have not yet come into vogue; but I can see the faint beginnings of these pastimes, and I venture to

prophesy that both games will become popular, amongst miners, within twenty years.

Of other amusements, such as pitch-and-toss, gardening, bee and poultry keeping, dancing, institutes and clubs with their reading, games and billiard-rooms, boating and rowing on sea and river, space will not permit of any detailed mention. But there is one sport which has lately come to the front, and is worthy of notice as being the only form of out-door amusement participated in by both sexes. I allude to bicycling. Five-and-thirty years ago, I doubt if there were more than half-a-dozen bicycles in the North of England. Of these I had one, my brother another. It was some years after this, before they spread into the colliery villages, and not until quite recently that the wives and daughters of the miners participated in the amusement.

An unamiable feature in the character of the miner, and I am afraid in that of other members of the working classes—I see that Lady Bell in her book, *At the Works*, notices it also—is that he does not consider his women-folk when catering for amusement. The young women amongst the miners do not, as a rule, go out to work. They can, therefore, earn no money for themselves, and are dependent upon their fathers and brothers. Until bicycling was introduced, their need for recreation was not considered in any way; except for dances, and an occasional picnic where their presence was required in the interests of the other sex. I am afraid that this, too, may be at the bottom of their being indulged with bicycles; the men find it rather dull to ride alone; and still more dull to ride in company with a young woman on foot.

It is a great pity that, in this matter of recreation, the interests of the other sex are not more considered by the working classes. It seems to me that nothing but good to both would result. Only last week, in looking over a workmen's institute in a colliery village and finding it in the untidy and dirty condition with which those who are in the habit of visiting these institutions are only too familiar, the thought struck me that if the women were members as well as the men what a scrubbing and cleaning there would be, and how much more cheerful, pleasanter and sweeter would the rooms be made to look. And

why should they not be members? At that great institution housed under the same roof with ourselves, of which Newcastle-upon-Tyne is so justly proud, women are equally eligible with men for every privilege of membership; and the rooms, lectures, books, management, etc., are shared in equally by both sexes. It is some years now since the middle classes awakened to "the rights of women" in this respect. I hope I may see in the introduction of bicycling for women into the colliery districts that this awakening is spreading to the miners also. It is a distinct step in advance, as is also the dying-out of such cruel sports as cock-fighting and rabbit-coursing.

It is interesting to make a comparison between the space afforded in the newspapers to popular sports at the period when this Institute commenced its work and to-day. Such a comparison can only be of an approximate character, and it may be as well to make it by taking the pages of *The Newcastle Chronicle*. *The Newcastle Chronicle* was first published as a daily newspaper in 1858. It was a small paper, with four pages each of six columns; and it used to give on an average about one column each day to sport, the news being confined chiefly to horse-racing; whilst, as a special condescension, there was the result of a boat race or wrestling match of more than average importance, and possibly the bare scores of a cricket match of the first class. To-day the paper will give from eight to twelve columns of sport, the news embracing games and recreations of every sort, from a rabbit running to a Derby, and from a boxing bout between obscure pugilists to a test match. And in that time, roughly speaking, the population of the two counties has risen—the figures are those of the nearest census years—from 993,856 to 1,790,188, or almost double in the fifty years. If we take it, then, that the space given to sport is now ten times what it was when the newspaper started, and remember that the newspaper is now three times as large as it was then, we find that it devotes, comparatively speaking, a little over three times as much space to sporting news as it did fifty years ago; so, if we take into account the doubling of the population, there is still reason to presume that the public interest in sport, as reflected in the attention devoted to it by the press, has increased rather than diminished.

His Relations with Capital.

When our Institute was founded, fifty-five years ago, there were no trade organizations for the fixing of wages and other terms of employment, such as we have at present. Unsuccessful attempts had been made from time to time by the miners of the two northern counties to unite themselves together for the purpose of obtaining better terms from their employers, and also for the passing of Acts of Parliament to better their condition. These attempts, however, did not meet with much success, and their failure appears to have been due not so much to the strength of the masters, as to internal dissensions amongst the miners themselves. Anyone reading the history of this, and other movements amongst miners, cannot but be struck by their want of confidence in their leaders, a want of confidence which is almost as apparent now as it was sixty years ago, and is the despair of their well-wishers.

According to Mr. Richard Fynes, the first attempt to form a union was made in 1809; and, although several unions were formed and broken up during the succeeding fifty years, it was not until 1865, when the attempt to combine the two counties together was finally abandoned, that the present associations (as we now know them) were formed. In that year, at the suggestion of Mr. Thomas Burt, Northumberland seceded from the union of the two counties and formed the present Northumberland Miners' Mutual Confidence Association, to be followed, a few years afterwards, in November, 1869, by the formation of the Durham Miners' Association. It is very largely due to the ability and devotion of two men, Mr. Thomas Burt and Mr. William Crawford, that both these institutions have been more fortunate than their predecessors.

The coal-owners appear to have been combined together from, at any rate, the early fifties; but the Northumberland and Durham Coal Owners' Associations, as now constituted, were not formed until 1867 and 1872 respectively.

Prior to these dates disputes were usually settled by hard fighting, as has sometimes been the case since. But, although regrettable incidents have occasionally occurred, it can be said to the credit of the North of England that never have such scenes been enacted as disgraced labour disputes in Manchester and Sheffield during the fifties and sixties; and are disgracing parts of America, even to the present day.

Since these dates, the above associations have represented the coal-trade of the North of England in fact as well as in name. And when, as has occasionally happened both in Northumberland and in Durham, the men have not been guided by their representatives upon these bodies they have had cause to regret their want of confidence. Other movements, too, took their rise in the sixties which have had a very important influence, an influence for good, upon the miners of our northern counties.

In 1861, the first co-operative store was established at West Cramlington, from which have radiated stores into all the colliery villages.

In 1862, the Miners' Permanent Relief Fund was instituted, an outcome of the Hartley accident of January in the same year. At the first annual meeting, held in May, 1863, it was announced that about 8,000 persons had joined the association. In spite of the Compensation Act of 1897, which many people thought would have injured the fund, it has gone on growing steadily from year to year, until at the last audit in December, 1906, the membership was 165,981; the income, £177,249; and the accumulated funds £398,201.

The establishment of science-and-art classes, and the lectures of Mr. William Rowden in the colliery villages of Northumberland and Durham, all took their rise about this time, and have been of great value. Not only in giving information upon many useful and interesting topics, but in educating the miners in the true meaning of education, strengthening their minds, broadening their views, and teaching independence of character, and preparing the way for the next stage in the industrial development of the coal-trade of our northern counties, namely:—The discussion of trade questions between masters and men upon an equal footing, the recognition of the fact that labour is interested in the coal-trade equally with capital, and that if capital, as responsible for the proper working of the mines, must be permitted to work them in its own way (so long, of course, as it conforms with the various Acts of Parliament regulating the industry), labour is entitled to have a voice in deciding upon what conditions as to wages and hours of work it will consent to be employed.

Acting upon these lines, the Durham Joint Committee was established in April, 1872; and the Northumberland Joint Com-

mittee in February, 1873. Of the original members of these committees, twenty-four in number, though I am happy to say there are several still living, only one active member, Mr. J. B. Simpson, is left. The functions of these committees are to settle local disputes, within the rules of the associations, questions affecting these rules being settled by the associations themselves. During the thirty-three years of their existence, the joint committees have amicably settled thousands of disputes, many of which would otherwise have resulted in stoppages of work; and it is very rare, if ever, that their decisions have not been loyally accepted by both sides.

But the court, which it appears to me should be the final court of appeal, is becoming more and more a court of first instance; and its time is wasted over trumpery disputes that ought to have been settled at home. The result is congestion; and really important cases, causing much friction at the collieries, cannot be heard until several months after they have arisen. The fact that the responsibility of coming to a decision can be put upon the joint committee seems to have taken the backbone out of the representatives of both parties at the collieries; and they are no longer capable of assuming responsibility themselves.

The joint committee, like the telephone, has great advantages. But both have, to my mind, a very serious, and, I am afraid, far-reaching defect: that they destroy individual initiative and sense of responsibility; and so in time must weaken the moral fibre of the nation. At one time, when a man was in a difficulty he was obliged to worry through by himself, and did so. Certainly this was to his own benefit and in the majority of cases to the benefit of his employer, whether that employer was the owner of some industrial undertaking or the State itself, as the man upon the spot is usually best able to judge what ought to be done, and is in a position to act promptly. But now he runs off to the telephone, or joint committee, and throws the responsibility upon someone else.

Various schemes have been adopted for mutually settling rates of wages and other matters outside the powers of the joint committee, without recourse to strikes and lock-outs. Discussion across the table at meetings of the associations of masters and men was a great improvement upon former methods, but

not altogether satisfactory, as, in the event of disagreement, there was no way, short of arbitration (a tedious process), of amicably settling the point of difference.

In spite, however, of this objection to arbitration, several important differences were determined in this way during the years 1874 to 1877; and it was as the outcome of these arbitrations that the method of settling wages disputes by a sliding scale, based upon selling prices, was adopted. If not evident before, it became evident in the course of these arbitrations that wages were very largely a question of selling prices, and this point was emphasized by the late Lord Herschell, amongst others, in one of the awards. It was suggested that wages might rise and fall with the rise and fall of selling prices, and so automatically settle wages, the only difficulty being to determine the relation that should be maintained between these two factors. After considerable negotiation, a sliding scale was agreed to in Durham in March, 1877, followed by one in Northumberland in November, 1879. By these scales, modified from time to time, wages were regulated in the two counties for about twelve years. But it became evident that other factors, besides selling prices, must be taken into account; or that the relation between wages and selling prices, that had been agreed to, was not a reasonable one. Be this as it may, the sliding scales for automatically regulating wages were abandoned in both counties; and the present arrangement, namely, a conciliation board with an independent chairman, whose decision should be final in default of agreement between the two bodies, was established in Durham in 1893, and in Northumberland in July, 1894. The conciliation boards, although mainly guided by selling prices, can, and do, take other factors into account.

The above methods of settling industrial disputes are none of them perhaps perfect, but under their guidance there has not been a general strike in Durham for over fifteen years and in Northumberland for more than twenty years. They are, I believe, the best methods possible at the stage that we have now reached in industrial evolution, and cannot be improved, except in detail, until a further stage is reached, when the identity of the interests of capital and labour being recognized by everybody, as they are now by the few, disputes between labour and capital will become impossible.

And here, to digress for a moment, people appear to me to be apt to forget that circumstances alter cases, and looking down from the elevated plane that we have now reached in social development (a plane which will in its turn be looked down upon a few generations hence) are inclined to find fault with the actions and mode of life of their forefathers; oblivious of the fact that they had not reached the stage of civilization when our present methods would have been possible, or perhaps even desirable. To take a very extreme case, slavery, which everyone now rightly condemns, was probably both necessary and desirable at one period of the world's history. Much as we may approve of our present methods of settling disputes, and superior as they may be to those in vogue at the birth of our Institute, each was probably suited to the times in which it was practised, and a conciliation board would have been as impossible in 1850 as the arrangement that will come into force in 1950, whatever it may be, would be impossible now.

There is no standing still. Change there always has been and always will be whilst this world lasts, in one direction or another; sometimes for the better, sometimes for the worse; on the whole, I hope and believe for the better, though we have had, no doubt, temporary set-backs from time to time. It will be interesting and useful to consider the direction along which we are likely to travel in the future. One or other of two paths we shall, I believe, follow, the one leading towards socialism: the ownership and exploitation of the mines by the State. The other towards co-operation: the ownership and exploitation of the mines by the workmen engaged in them. The first, I believe, would lead to disaster, the last to the advantage of capital and labour alike, and through them to the country generally.

Socialism has been a good deal before us during the last few years. By this I mean that it has been a good deal talked and written about. Not that we are any nearer to a purely socialistic State at the present time than we have ever been. To quote Mr. W. H. Mallock "Such a State has never existed, and there is no reason to suppose that it ever will."* But attempts may be made to found such a State; and as these attempts, if

* *The Times*, October 4th, 1906, page 10.

ever made, must, in my opinion, end in disaster, any tendency towards socialism in the relations of masters and men is to be avoided.

With the object of socialism, the betterment of the condition of the people, we are all in sympathy. It is as to the means that should be adopted for the achievement of this result that thinkers differ; and I believe that the object which the socialist thinks, rightly or wrongly, can be obtained through the State, can be obtained, and obtained much more satisfactorily, by co-operation. It is therefore in the direction of co-operation that I look for my ideal in the future organization of our industrial system.

The working-man, however, has hardly yet reached the stage in social evolution that would enable him to conduct successfully colliery enterprises. No one can read his letters and speeches in the press without realizing his ignorance of the elements of political economy as applied to coal-mining, to commerce, and to business generally. It is evident that there is a very prevalent belief amongst the miners as a body that—to quote one of their leaders and a county councillor—"In future, wages should not be ruled by prices, but prices should be ruled by wages"; and, until miners realize that this is impossible, it will be hopeless for them to undertake to run a colliery of their own. But this general dissatisfaction with prices as a basis for wages and the exaggerated idea of the large profits made in coal-mining will probably lead to profits, instead of prices, being adopted as the next step for a basis in determining wages.

The difficulties in the working of coal have increased so much of late years, that the efficiency of the miner has decreased; and a relation of wages to selling prices that the coal-owner could afford to agree to twenty years ago, he can agree to no longer. It is only due to the fact that selling prices have kept up at a higher average during the last eighteen years than they did when the various sliding scales were established, and that these sliding scales were more favourable to the masters in their higher, than in their lower reaches, that they have continued for so long the main factor in settling the rate of wages. Just as the present plan has had an educative value in giving the miner a knowledge of prices, so will an agreement based upon profits have an educative value in giving him a knowledge of the profits

that are made in the coal-trade. It will show how erroneous is the prevalent idea of very high profits; but, at the same time, it will show that, taking one year with another, reasonable profits can be made. And, with the knowledge that the miner has of the losses due to matters within his own control: such as excessive supervision, idle time, careless making of places, dirty coal, etc., losses which we may hope would not be allowed to take place in a colliery owned by the persons employed in it, and where each workman was interested, not only in himself doing his very best, but in seeing that his brother workmen did their best also; large economies could be effected, and consequently larger profits earned.

There are, however, other points besides political economy and commerce upon which the miners as a body require further training before they can hope to manage a colliery successfully; and a very important one, is that they must learn to put more confidence in their leaders. There appears to be among the miners of Northumberland and Durham, an inherent distrust of those in authority over them: whether they be put over them by circumstances over which they have no control, as are the agents and managers of the collieries; or whether they be their own chosen leaders. An essential for the success of any industrial undertaking, and more particularly for one like a colliery, where there must necessarily be very large variations in profits, is that it must be under the control of a thoroughly capable man who has the confidence of his employers, and consequently a practically free hand to do what he knows to be right. This confidence I am afraid, during bad times at any rate, would be withheld from the agent of a miners' co-operative colliery. His hands would be tied, and the undertaking would inevitably come to grief.

I do believe that a co-operative colliery *could* tide over a few years of bad trade. From a careful examination of the results of trading during bad years I find that, at any rate, the receipts would be sufficient to pay a so-called "living wage"; and so long as the men got this they could wait for the prosperous years for high wages and for interest upon their capital. Moreover, after a few years, a reserve fund would have been set aside sufficient to pay good wages and interest on capital during

the bad years. It is, of course, another question whether a co-operative colliery *would* tide over the bad years. I am inclined to think that at the present time it would not.

Another difficulty that is sometimes mentioned in the way of co-operative collieries is the want of capital amongst working miners. This, if it exists, is in my opinion due, not to want of opportunity, but to the want of a little self-denial on the part of our young men. The capital required to start a colliery, of course, is a variable amount, depending upon the circumstances of each case, but it may be taken roughly at 10s. per ton of annual output or £150 per hand employed. And the question is, can such a sum as this be raised by the workmen? There cannot, in my opinion, be any doubt upon this point. If the miner could be persuaded to do what the middle classes do, namely, postpone marriage until seven or eight and twenty, instead of marrying soon after he comes of age, there would be no difficulty in the matter. Moreover, the girls would marry later in life. The lassie of eighteen, who appeals to the lad of one-and-twenty, would not satisfy the young man of twenty-seven or twenty-eight, and the delay upon the part of the girl in undertaking the responsibilities of matrimony for four or five years would give her the opportunity of learning some of the duties of a wife and mother; and also of acquiring more physical strength, without which, however willing and capable a woman may be, these duties cannot be carried out either with comfort to herself or to the physical well-being of her descendants.

A miner makes as much money at four- or five-and-twenty as he does at any time of his life; and the support of a wife and four or five young children can be fairly put at about 20s. a week. In other words, if the married miner of five-and-thirty can support a wife and family, the unmarried miner of five-and-twenty can save 20s. a week. By the time therefore that he was seven-and-twenty he could have saved £300, and other classes of labour a smaller sum in proportion. It would not be necessary, moreover, that the whole of the capital should be held by the workmen interested in a colliery; some could, and no doubt would be supplied, as at present, by the general public.

It is also evident from the large sums that miners have already saved and invested in various undertakings, that want of capital would be no bar to the establishment of co-operative

collieries; and in their unions, building societies, savings banks, benefit societies, relief funds and co-operative stores, they already have vast sums invested. This fact, I think, will make them very shy of socialism, when socialism is no longer academic, but becomes a question of practical politics. In distributive co-operative societies alone I estimate that the miners of Northumberland and Durham have £2,000,000 invested. These took their rise in the North of England in 1861 at West Cramlington. Mr. R. Fynes gives a very graphic account of the commencement of the undertaking, too long to quote here, but it was a success from the very first. At the end of the first quarter, goods to the value of £449 14s. 2½d. were sold, and the spread of the movement is shown by the fact that during the quarter ending on February 2nd, 1907, the Cramlington District Co-operative Society, Limited, sold goods to the value of £47,973 0s. 1d.

Productive co-operation, however, in which for the moment we are interested, has not been a success, so far as mines are concerned. The nearest approach to success being found, I think, in the "tut-work," a species of productive co-operation, still in vogue in Cornish mines. Every attempt to start and run a co-operative colliery so far has been a miserable failure. Of these attempts there have been several.

Using the term "co-operative colliery" in its most extended sense, that is, including all those in which the workmen were paid something over the current rate of wages in the form, for example, of a percentage upon the profits; as well as those in which they were themselves the owners of the colliery, the following examples have come under my notice.

The first attempt, so far as I know, to work a colliery upon co-operative lines was made by Messrs. Briggs in 1865, when the firm became a limited liability company. It was stated that "everything was taken at the value at which it stood in the books of the firm; while two-thirds of the capital, and the full control of the practical management were to remain in Messrs. Briggs' hands. . . . . The allocation of profits was as follows: whenever, after providing for the redemption of capital, etc., the divisible profits exceeded 10 per cent. per annum on the capital of the company, the workpeople, including managers or agents,

at fixed salaries, were to receive one-half of such excess profits to be distributed amongst them in proportion to, and as a percentage upon their respective earnings during the year. The company was, at this time, paying about £1,000 a week in wages." For ten years this arrangement appears to have worked satisfactorily, the dividends to the shareholders varying from 13½ to 25 per cent. (during the two years preceding the arrangement they had averaged 4½ per cent. only, with, of course, no payments of bonus) and the yearly bonus to the men from £1,740 to £14,256; and, in addition, Whitwell Main colliery was bought, mainly out of profits, and large sums were allocated to depreciation and reserve funds.

During the last half of 1874, however, trade fell off, and in 1875 the men throughout the district were required to submit to a reduction of wages. After a strike of four weeks, in which Messrs. Briggs' workmen joined, the matter was referred to arbitration, and a reduction was awarded by the umpire. In consequence of the men taking part in this strike, the bonus system was abandoned in February, 1875, and thus ended, so far as I know, the only attempt at a co-operative colliery that has had any measure of success.

Several other attempts to work a colliery on co-operative lines have been tried. In 1866, the South Buckley Coal and Fire-brick Company, Limited, was registered; shares were taken, amongst others, by Mr. Thomas Hughes, the Marquis of Ripon, the Earl of Derby and the Duke of Devonshire, and of a capital of £50,000, £10,000 was to be reserved to the workmen. This company failed very soon after its inception.

In 1872, the Darwen Mining Company, Limited, with a nominal capital of £12,000 was floated by some members of the Darwen Industrial Society. A colliery, opened at Whitebirk, near Blackburn, was worked for a time, but it did not pay. The company went into liquidation in 1882, and the colliery was taken over by the Darwen Industrial Society who were large creditors. The society continued to work the colliery until 1889 with a fair amount of success, when the pit was closed and the plant sold.

The Co-operative Mining Society, Limited, in which the miners of the North of England were large investors, was registered on January 8th, 1873. "The shares were transferable

and of the value of £5 each. They were to have a first claim upon the profits equal to 10 per cent. per annum. After this claim was satisfied, a portion of the profits were to be devoted to the reserve fund and the remainder was to be divided equally between labour, capital and trade." The movement was very generally supported by the miners of Northumberland and Durham, 2,163 shareholders joined with a paid-up share capital of £35,796; and Monkwood colliery, near Chesterfield, was bought for £68,000 in April, 1874. The undertaking, however, failed, and the company was wound up in 1877, the shareholders losing the whole of their capital. Into the causes of the failure I do not propose to enter, except to point out that, purchased at a period of inflation, too much, no doubt, was paid for the colliery; and although it was nominally co-operative and enthusiastically supported by the miners of Northumberland and Durham, the Monkwood workmen declined to become shareholders in it.

In addition to the companies mentioned above, the following were floated during the seventies:—The Eccleshill Coal Company, Limited, registered in April, 1872. The Leeds and Yorkshire Co-operative Coal-Mining Company, Limited, registered at the end of 1872. It was better known, perhaps, under the name of the Lofthouse Colliery, Limited, which is no longer co-operative. The Leeds, Morley and District Co-operative Coal Society, registered on December 28th, 1872. The Alston Co-operative Coal Company, in March, 1873. The Ayrshire Coal Mining Society, in October, 1873. The Scottish Co-operative Coal Company, Limited, in 1873. The South Yorkshire Mining Co-operative Society, registered on July 21st, 1873. The Tipton Green Colliery Company, Limited, started in 1873, and the Leeds Co-operative Society invested £19,000 in it The Broughton Moor Co-operative Mining Society, registered on January 20th, 1874. The United Coal-mining Society, registered on January 26th, 1874. The West Yorkshire and North Staffordshire Co-operative Coal-mining and Building Society, registered on April 22nd, 1874. The Shirland colliery was purchased by the South Yorkshire and North Derbyshire Miners' Association early in 1875 for £69,000. The Derbyshire and Nottinghamshire Co-operative Mining Society, registered on February 13th, 1875. The Spring Vale Colliery Company was taken over by the Wholesale Co-operative Society, Limited, in 1880. Very few of these

companies had more than two or three years' existence, and every one failed as a co-operative colliery. The history of their misfortunes may be read in the *Co-operative News*, and a very excellent résumé by Mr. Benjamin Jones.*

After such a record of failures it seems hopeless at first sight to look to the establishment of co-operative collieries in the near future as the next step in advance, in industrial organization. But a little reflection and a consideration of the circumstances under which these collieries were floated will go some way to dissipate this conclusion. With the exception of Messrs. Briggs, and the South Buckley Company, all these undertakings were started during the years 1872 to 1874, a period of inflation, the very worst time for commencing a colliery, even upon recognized wellknown lines, and utterly impracticable when the colliery must necessarily be of an experimental and tentative character. There is not, of course, this excuse for the failure at Messrs. Briggs' colliery. It is forty years ago now since it was started, and thirty years since it failed as a co-operative concern, and at this distance of time, with but meagre information at my disposal, it is impossible to say exactly why it failed and if failure was inevitable. But both masters and men have learned a great deal since 1875; and I do not think that a North of England colliery at any rate, that had been carried on successfully for ten years on the bonus system, would be abandoned now-a-days. To begin with, the immediate cause of its failure was a general strike, and this we have not had in the North of England for fifteen years. In addition to the unfortunate time selected for the launching of these schemes, not one of them appears to have been really co-operative, that is, collieries in which the workmen engaged at the mine themselves owned, if not all, a considerable proportion of the capital; though this was no doubt the intention of the promoters in most cases.

To quote the prospects of the Co-operative Mining Society, Limited, floated by Mr. Thomas Burt, Dr. Rutherford, Mr. W. Morrison, Mr. E. Lowther and others:—"But what is wanted is, that the miner shall feel that the pit in which he works is his own; and, in order to do this, it must be open to him, if he chooses to invest all his earnings there. To this end, the miners of Northumberland and Durham have resolved to have collieries

* *Co-operative Production*, 1894, vol. ii., pages 444 to 539.

of their own. . . . It is intended that every worker shall be a member, etc." Unfortunately, I consider, this did not turn out to be the case in practice. The miners of Northumberland and Durham became shareholders, and put their money into the Monkwood colliery; but I understand that not one of the workmen employed at the colliery was a shareholder, though urged to become so. In the face of this, the colliery, even if it had been a success, would have been no triumph for co-operative production.

As I have already said, I do not anticipate that the miners will become the owners of the collieries in which they work for many years yet; though I do look forward to this, and not to socialism, as the final solution of the industrial problem, so far as anything can be final in this world. Great as the advances are that the miners have made since the foundation of our Institute, they require further education in commercial knowledge, in thrift, in confidence in their fellowmen, before they will be capable of carrying on with success an undertaking so uncertain as a colliery and subject to such fluctuations in value. It has been said of a North of England royalty-owner, who not only owned the coal but worked it himself, that he made half-a-million one year and half-a-crown the next; and he thought it therefore best to let his mines and be content with a smaller, but more regular income.

How best to deal with these fluctuations is the problem now, as it was 3,600 years ago. Good years have always been followed by bad years, and the seven lean kine, now as then, will devour the seven fat kine, unless means are taken to prevent them. Now as then, foresight and thrift are the only solutions of the problem. Provision must be made in the good years for the bad years that will surely follow. It is the lean years that will try co-operative collieries, and reserve-funds must be set aside during the fat years to meet this. But I am afraid that whatever hopes we may have for the future, and hopes I certainly have, in the present state of education amongst the miners, not even such a leader as Joseph himself would induce them to make so necessary a provision.

In conclusion, I thank you for the patience with which you have listened to this address—a patience which may tempt

me to inflict upon you at some future date the remaining sections that I have already mentioned and had originally intended to include in it.

Mr. J. B. SIMPSON, the oldest of five past-presidents present, proposed a vote of thanks to Mr. Merivale for his address. It was the only address that had been delivered during the past nine years, with one exception; and the subject was somewhat of a departure from those included in the objects of the Institute. No doubt intelligent and healthy sports would be a great advantage to the rising generation, and would have a good effect on the working of coal. The President's very able and lucid address had certainly put before the members a great field for thought.

Mr. THOS. DOUGLAS (past-president) in seconding the vote of thanks, said that the address would stimulate the members to do more than had hitherto been done in the endeavour to promote the moral elevation of the men amongst whom their lives were spent.

The vote of thanks was cordially adopted.

Mr. J. M. LIDDELL (Cobalt, Canada) wrote that it would be conceded by most workmen that there were two great classes of work which must be recognized: (1) that in which all work was done by time, at definite wages; and (2) that in which work was done by the piece, under hours and at prices agreed upon; and that many sorts of work must be done by one or the other of these methods in order to get most benefit for the worker, for the investor and for the public, which was materially concerned. Now, the greatest industries were capable of consideration in this light. The military and civil services, and many manufacturers of materials required for them, fell properly into the first-class; while others such as farming, fisheries, etc., fell into the second class, and were let to private individuals or companies. In this second or contract class, the coal-producing industry naturally found its place. It had been tried for generations and in various ways, and shown to be a contract-job. The only satisfactory method for all concerned was to let contracts for the discovery, winning and working of coals for public use and for export. There was much tendency for trades unions to review and to desire to control the conditions under which such contract-

rights obtained, but they should reflect that any action which hampered the negotiation of contracts must damage all the parties concerned. Money was the blood of the industrial body, and it became feverish as risks increased: it was liable to panic when conditions of investment were upset, the body was liable to be drained white, and labour, which formed the bone and sinew, to be left helpless. The Latin fable of "the belly and its members" was still sound wisdom, and it was very much to the point to-day.

DISCUSSION ON THE EXPLOSION AT URPETH COLLIERY.*

Mr. A. L. Steavenson (Durham) said that everything at Urpeth colliery had been in the best possible order; every rule had been carried out most strictly, with the exception of that disregarded by the men who suffered in the accident; and the coroner's jury, after stating in each case the immediate cause of death, found that they were "accidentally caused by an explosion of fire-damp through shot-firing."† However, there was not one word of evidence in the report to show that any gas was present; and, on the contrary, there were repeated proofs in the report that gas was absent. The reports of the mine-officials showed that gas was not present up to 10 a.m. on the day of the explosion.‡ Mr. Atkinson stated that "gas was . present in sufficient quantity to prevent an ordinary safety-lamp being taken to the face,"§ but this was during an examination made some time after the explosion; but he added that he did "not think that Greenwell would have fired the second shot had gas been showing on his lamp."‖ He (Mr. Steavenson) specially pointed out that there was "a supply of clay for stemming shot-holes";¶ but "none of the stemming [used] was of the clay provided for the purpose."** This breach of the twelfth General Rule was the key to the accident; and the explosion originated in the "small coal and dust" stemming used in the shot-hole, and not in the gas nor in the explosive. The men would select the smallest

* *Report to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion of Fire-damp and Coal-dust which occurred at Urpeth Colliery, near Birtley, in the County of Durham, on the 17th December, 1906,* by Mr. J. B. Atkinson, M.Sc., 1907 [Cd. 3494].

† *Ibid.*, page 4. ‡ *Ibid.*, page 9. § *Ibid.*, page 10.

‖ *Ibid.*, page 14. ¶ *Ibid.*, page 10. ** *Ibid.*, page 11.

coal for insertion in the shot-hole; and the act of ramming would crush it to dust. Even with westfalite, there would always be slight flame, and that flame would ignite the dust used as stemming. He thought that the attention of miners and deputies should be specially drawn to the danger of using coal-dust for stemming. The report itself was excellent, and the facts were so marshalled that everybody could understand them; and he thought that every manager should particularly direct the attention of his officials to it.

Mr. J. G. WEEKS (Bedlington) said that he was not quite satisfied that this explosion had arisen entirely from coal-dust; although the coal-dust used instead of clay in the stemming would under certain conditions of course aggravate an explosion. He would suggest, in the interests of safety, where two shots were fired in close proximity, although the place had been once examined for gas, that the place should be re-examined before the second shot was fired. It was possible, even if no gas was present when the first shot was fired, that some pent-up gas might have been set free by firing that shot, and on re-examination it might have been discovered before the second shot was fired.

Mr. JOSEPH DICKINSON (Manchester) wrote that the facts were so lucidly given by Mr. J. B. Atkinson that any ordinary miner might draw his own conclusions, apart from those stated, as to the dangers of dust. The late Sir F. Abel's remarks* on the luminosity of flame might be traced further back. Prof. W. T. Brande† stated that if they blew any fine substance through flame in fine dust, its brightness would be proportionately increased, although the solid matter might not be inflammable, as, for instance, if they sifted a little lime or magnesia into or through it.

Mr. JAMES ASHWORTH wrote that the *Report* on the Urpeth colliery explosion contained several points of considerable interest, for instance, it was probably the most direct acknowledgment, made by any inspector of mines, that "dry" coal-dust was a controlling factor in bringing an explosion to a

* *Report on the Results of Experiments made with Samples of Dust collected at Seaham Colliery*, by Prof. F. A. Abel, 1881 [C.—2923], page 9; and *Final Report of H.M. Commissioners appointed to inquire into Accidents in Mines*, 1886 [C.—4699], page 155.

† *Manual of Chemistry*, 1841, pages 223-224.

termination. Other explosions had demonstrated that watering a mine, even very efficiently, was no safeguard against the extension of an explosion, and many witnesses (including Mr. Henry Hall, H.M. inspector of mines) when giving evidence before the present Royal Commission on Mines had stated that watering in deep mines seriously damaged the roof and sides, and made them unsafe. Evidence had also been given that, if men were to work with any degree of comfort and with a due regard to health, the air of a deep mine must be dry. They were thus brought into the presence of a vital point of difference of opinion, with the non-watering advocates on one side; and, on the reverse, those who could not see any degree of safety except when watering was carried out extensively and efficiently. He (Mr. Ashworth) persistently advocated, and endeavoured to prove, by reasoning from actual facts, that watering could not protect a colliery from the extension of an explosion; that a dry mine was safer than a damp one; and that there were other risks, entirely apart from the possibility of the propagation of flame along the roadways of a mine, against which watering could have no deterrent effect—nay, it was more than probable that it materially assisted, namely, "air percussion" and "detonation." He (Mr. Ashworth) meant by these terms similar effects to those which caused simultaneous explosions at long distances apart at the Albion, Quarter, Tylorstown, Udston, Universal, and other collieries; which caused shots to be ignited and fired at a distance of more than a mile at Tylorstown, without any trace of flame being found on most part of the intervening roadway; and also at the same colliery, where a blower of fire-damp was ignited in the 8 hours dip, lower west district, Six-feet coal-seam, without any evidence of actual flame being found on the adjoining roadway.*

He (Mr. Ashworth) believed that the Urpeth explosion was a distinct exposition of the effects of detonation and air percussion, as all the necessary conditions were stated to have been present: (1) Two shots of westfalite were prepared in a heading, containing at least 2 per cent. of gas, and the safety-lamps in use were totally incapable of detecting it; and (2) the second shot was fired into an atmosphere saturated with moisture and mixed

* *Reports to the Right Honourable the Secretary of State for the Home Department*, by Mr. Robert Woodfall and Mr. J. T. Robson, 1896 [C.—8059], plan No. 2.

with the products of the explosion of the first shot: thus the second shot was fired into an atmosphere capable of being detonated, and it was detonated. Consequently, the permitted explosive caused an explosion in a mine, under conditions which, if reproduced experimentally on the surface under like conditions, would probably cause neither ignition nor detonation. There was no suggestion and no evidence that either of the shots was blown out or overcharged, or that they did not do as much work as they were required to do; and, consequently, if a naked flame fired the assumed mixture of over 2 per cent. of fire-damp and air, whence did it arise? On the other hand, assuming the conditions that were described in Mr. Atkinson's report, that there was no actual flame and in no sense a blown-out shot, but a detonating effect, the origin of the explosion was accounted for, and they were brought close up to an extremely awkward fact, namely, that explosives might be improved until ignitions of the surrounding atmosphere could not be produced experimentally, and yet one factor, which their present knowledge of explosives did not enable them to control, might carry a dangerous detonating vibration or percussive effect into distant parts of a colliery, and thus initiate other explosions of mixtures of fire-damp and air. In his (Mr. Ashworth's) opinion, blasting with the highest class of permitted explosives could not be made safe in a dusty, fiery mine until they were able to control detonating and percussive effects.

The position in which the body of Barnes was found showed that he was instantaneously rendered unconscious by air-percussion and then poisoned by carbon monoxide. Detonation and percussive effects were always most destructive at the face of narrow headings; and, therefore, Greenwell and Suggett were not affected in the same way as Barnes, and they were able to run some distance outbye before the after-damp killed them. The effect of the explosion on Barnes did not support the conclusion expressed by Mr. Atkinson:* nor did the Universal explosion support it; as the only man who escaped alive was in the roadway between the east and west sides of the pit, and must have been exposed to the passage of flame and force if they

* *Report to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion of Fire-damp and Coal-dust which occurred at Urpeth Colliery, near Birtley, in the County of Durham, on the 17th December, 1906,* by Mr. J. B. Atkinson, M.Sc., 1907 [Cd. 3494], page 14, lines 31 to 36.

had travelled, either from the east to the west, or from the west to the east, in the manner in which such effects were generally supposed to travel. He (Mr. Ashworth) did not look on the Urpeth explosion as one which ought to be designated a coal-dust explosion, as it was primarily due to fire-damp, and the flame was principally found in the return-airway, showing that it followed the mixture of gas and air until the percentage became so small by reason of air leaking through the stoppings and doors between the intake-airways and return-airways that it was too weak to burn. The great force, which tore out the steel girders, was doubtless due to the ignition of gas lodged above them in the broken faulted ground; and the coking of the dust was consequently due to the heat of the explosion of gas and not primarily to an explosion of dust. Another point concerning the coking of dust at Urpeth colliery deserved attention, namely, that the roads where it was found were naturally wet, and the air was saturated with moisture. A similar result was found at Udston colliery, the coking being heaviest in the wettest places; and similar results were found at Wingate Grange colliery. These facts could not, therefore, afford much satisfaction to those who pinned their faith to watering as a preventive of great disasters in collieries.

In conclusion, a pertinent query arose out of the *Report*, namely, if a mixture of 2 per cent. of fire-damp and air was a dangerous atmosphere in which to fire a shot of any permitted explosive, why were not safety-lamps, capable of detecting 1 per cent. of fire-damp, adopted for the use of deputies and shot-firers? There were no complicated parts in such lamps; the cost was very slightly in excess of that paid for the bonneted lamps used at Urpeth colliery; and it seemed absurd to use a safe explosive in a colliery, but to fire it in an unsafe atmosphere. Further, if an explosive was used in a gaseous atmosphere, as at Urpeth colliery, without the shot-firer being aware whether or not the atmosphere was safe or dangerous, it was clear that the General and Special Rules of the Coal-mines Regulation Acts were not enforced.

Mr. Donald M. D. Stuart (Bristol) wrote that the *Report* was of considerable importance, as it recorded an explosion of coal-dust at the coal-face, an almost unknown event in this

country. A fundamental element in dangerous coal-dust was admittedly its fineness of division, such as obtained in main haulage-roads; but this condition was supposed to have no existence at the coal-faces or in the immediate neighbourhood, as the coal-dust there had been regarded as incapable of ignition by fired gas or shot-firing. This explosion therefore required careful discussion. If coal-dust at the coal-face could be ignited to develop explosion, the danger of propagated explosions was more serious than had been supposed, and the present consensus of opinion that watering the coal-face was unnecessary required re-consideration. The question might be conveniently discussed by recalling the conditions in the workings where the explosion originated. The presence of coal-dust at the face and in its neighbourhood, sufficiently fine to be ignited and propagate an explosion, was demonstrated in the extensive deposition of coked dust. The presence of gas was equally certain, as it was yielded regularly and accumulated on the derangement of the ventilation. The existence of both coal-dust and gas appeared to complicate the case, suggesting a dual influence; but it would be a great advantage to the discussion if the function of these agents in the explosion could be discriminated, and for this purpose it was well worth enquiring into the facts. The *Report* supplied direct evidence on the question of gas: the seam yielded gas in constant flow from the advance-faces, which was diluted and carried away by the air-current by means of close bratticing. There had been no sudden outburst of gas in the workings; there were no goaves: consequently, there could be no gaseous accumulation. The working-faces comprised three headways and a stenton, and the complement of labour appeared to be four hewers, and two putters with ponies. To ventilate these workings and the cross-cuts leading to them, no less than 12,555 cubic feet of air per minute were passed through a regulator: a very generous supply even for advance-faces in a gaseous seam. The result of this ventilation was clearly recorded on the day of the explosion and immediately antecedent thereto. The *Report* showed that, within 13½ hours of the explosion, the stenton and the headways had been examined three times by different officials, namely, Sunday at 9 p.m., and Monday at 3 a.m. and 5 a.m. (the explosion occurred at 10.35 a.m.); the officials found the places free of gas, and two recorded the fact in writing in the report-books.

These reports narrow the time down to within 5½ hours of the disaster; at that time (5 a.m.), the deputy observed that the brattice-cloth at the face was too narrow to reach the floor, and that some air could short-circuit; he then laid more brattice along the floor, and compelled the full current of air to sweep the face, thereby effecting a more thorough dilution and removal of gas than obtained when he made his examination. About one hour later, the deputy left the district in a fit condition for shot-firing, and gave charge at 9·50 a.m. to the incoming deputy, telling him to go direct to the district, as shots would be ready for firing. This deputy would reach the district about 10 a.m., make the examination for gas before shot-firing; and presumably he found no gas, as he fired the first shot. This shot did not bring all its burden, but left about a foot of socket on the hole; consequently the unexpended heat-energy of the charge was thrown into the stenton, and if gas had been present then it would probably have been ignited. There was no ignition, and it was obvious that there was no gas in the stenton within a very short time before the explosion. After firing the first shot, the deputy or hewer, or both, returned to the face of the stenton, took the cable from the discharged shot, coupled it to the wires of the second shot, retired to the central headways and fired it; and the explosion then occurred. The interval between the shots could not have exceeded 10 minutes; but it was suggested that gas might have been liberated from the coal-face by the first shot and accumulated there during this period. There was no evidence that the brattice-cloth was deranged by the first shot, or that the air-current was interfered with; and it was reasonable to assume that any fresh or abnormal efflux of gas at this time was carried away by the ventilation. During this interval of 10 minutes, and about midway, one or both of the men were at the face of the stenton with a safety-lamp raised to cast light upon the wires of the second shot near the roof to make the cable-connection, and if gas had been present it must have shown in the lamp without any special examination; and, in that case, the deputy would not have fired the second shot. The quantity of gas issuing from the coal-face of the stenton after both shots had been fired appeared to have been limited, as 10 hours after the explosion, with the main return-airway blocked by a heavy fall, and canvas-doors and brattice-cloths deranged, the accumulation was

inadequate to prevent momentary examination of the face with an electric lamp, although it was unadvisable to do so with an ordinary safety-lamp. The positions of the headways, however, showed that the gas in this advance-working had been already tapped. The left and central headways had probed the seam in advance of the stenton, and the right headways had advanced across its face; the gas in the coal in the immediate vicinity and in advance of the stenton had therefore been drawn off to a material extent. In these circumstances, it was scarcely possible to conceive that there was any appreciable gas in the stenton when the explosion occurred. It was suggested that there might have been 1 or 2 per cent. of gas in the air-current and that the dust raised and left in suspension by the first shot had determined its ignition. There was no doubt that such a mixture of air, gas and dust had been inflamed by experiment, but it would scarcely be suggested that 1 or 2 per cent. of methane with 98 to 99 per cent. of air possessed any thermal value to produce the phenomena of this explosion. There were other evidences by which the suggested ignition of dilute gas might be examined. It was recorded that the brattice-cloth in the stenton was only partially displaced; the common experience in ignitions of very small quantities of gas in bratticed roads was that the brattice was wholly displaced, especially when the return air passed on the inside as in this case; and a "smart explosion" or even a gaseous ignition would surely have thrown down all the brattice in the stenton. The air travelled from the face of the left headways, round the face of the central headways, thence to the face of the stenton and onwards through the face of the right headways, receiving the gas *en route*; probably the air-current contained the least gas at the left headways, but receiving successive increments at the central headways and stenton became most highly charged at the coal-face of the right headways. The records showed that the flame did not reach the coal-faces of the left, central or right headways; the hewer in the left one was not burnt, the brattice-cloth in the right one was not displaced; if the supposed gaseous ignition did occur in the stenton, it would in natural course follow the train of gas to the coal-faces of the central and left headways on one side, and the coal-face of the right headways on the other, in the same way as a train of gunpowder when lighted midway burns to both ends; and, in the absence of these extended effects, it was difficult to conceive that gas had been

ignited in the stenton. In view of the facts that the stenton was examined by three officials during the 13½ hours preceding the explosion and within ½ hour of the disaster; that the first shot was fired there within 10 minutes of the event; and that there was no gaseous ignition in the faces of the headways on either side of the stenton, although they were part of the same atmosphere, the conclusion appeared to be reasonably established that fire-damp was not an element in the origin of the explosion, and that coal-dust was the only explosive agent ignited by the second shot.

This conclusion involved the proposition that coal-dust *per se* at the coal-face and its vicinity could be ignited and cause a propagated explosion. The past experience of mining engineers in this country was opposed to this postulate. The records showed that the principal explosions originated in main or secondary haulage-roads, where the coal-dust was in a fine state of division. There appeared to be one exception only: the Apedale colliery explosion, in the year 1891, originated by a shot igniting coal-dust at the coal-face, corresponded with the explosion at Urpeth colliery in that important point. These two exceptions, to the practically overwhelming mass of mining experience, required careful consideration. The conditions at the coal-faces must be elucidated, to ascertain whether they compared with the condition of main haulage-roads; if the comparison existed, enquiry was necessary into the causes, as if the dangerous dust zone of the haulage-roads extended into the coal-faces they possessed a potential danger that either a gaseous ignition or a shot could develop into terrible activity. The behaviour of coal-dust in a coarse or granular condition, and in a fine state of division, when subjected to heat for the extremely short time that obtained in gaseous ignitions and shot-firing, was so distinct as to form a clear line of demarcation, on one side of which the granular dust was comparatively innocuous, and on the other the impalpable dust was inflammable, instantly yielding explosive gases and developing explosion. This was not simply an experiment of laboratory-practice, but the admitted practical solution of the fact, notwithstanding the numerous gaseous ignitions and enormous amount of shot-firing at the coal-face, that there had been no ignition of coal-dust there (excepting the explosions at Apedale and Urpeth collieries); while the very

limited shot-firing in the haulage-roads had frequently ignited fine coal-dust from atmospheric suspension, causing disastrous explosions. Applying these data to the explosions at the Apedale and Urpeth collieries, it would be expected that the coal-dust in the coal-faces was in fine division. In both collieries, the coal was blasted, and the effect of different blasting agents was well-known. The non-detonating explosive was generally described as "spreading" and rending the face of coal; the detonating as "local" and shattering the coal. If the hole in which an explosive was fired could be examined, the class of explosive used, whether detonating or non-detonating, could be determined: if non-detonating, the walls of the hole would be split open; if detonating, the walls round the charge would be pulverized, and a chamber of impalpable coal-dust produced. This impalpable dust was naturally deposited at the coal-face and in the neighbourhood. The powerful and instantaneous shock of detonation was concentrated locally in the coal-face, and necessarily the coal that had received this shattering impact gave off fine dust during the extraction and filling into the tubs. The records showed that a non-detonating explosive had been excluded from Apedale colliery some time before the explosion, and a detonating explosive substituted at the coal-face. The inevitable effect was the production of impalpable coal-dust in the face and neighbourhood, and finally its ignition by a shot, with a disastrous explosion. The *Report* under discussion showed that a detonating explosive was used in the coal-face at Urpeth colliery; and the explosion, with the accumulated residues of coked coal-dust, demonstrated that this explosive had produced coal-dust so impalpable that it was ignited by the almost instantaneous exposure to heat from the shot, and caused propagated explosion. The awful explosion at the Courrières collieries in 1906 was another illustration, as there also the explosion probably originated at the coal-face, where a detonating explosive was used; and it was believed that the disaster was due to the ignition of the coal-dust by a shot. There might possibly have been some other factor than the fine state of division of the coal-dust at Apedale, Courrières and Urpeth collieries, and feasible suggestions might be offered; but, as they could neither be affirmed nor denied, they would not assist this discussion, and the substantial fact remained that the coal-dust at the coal-faces of

these collieries was in the dangerous condition that obtained in main haulage-roads, and that condition was brought about by the use of detonating or shattering explosives.

It would be most useful to know how far this dangerous coal-dust prevailed at coal-faces. With the fact that over 11,000 tons of explosives were annually consumed in mines and quarries, chiefly in coal-mines, the greater proportion at coal-faces, and that only two explosions by ignition of coal-dust at coal-faces had been recorded, the danger seemed to be somewhat remote: it should, however, be remembered that, until comparatively recent years, a non-detonating explosive was exclusively used in coal, and non-detonating explosives were still used to the extent of over 68 per cent. of the total consumption. Further, the permitted non-detonating explosive, which might be assumed as used only in coal, was more largely consumed than any other on the permitted list; in fact, last year, the consumption was more than 18 per cent. of the total quantity of the 42 permitted explosives used. The freedom from explosions by ignition of coal-dust at the coal-face had been obtained with non-detonating explosives. The record of safety here had been broken by detonating explosives; and the explosions at Apedale, Courrières and Urpeth collieries were object-lessons of a new danger with coal-dust, created by these explosives. The nature of that danger was seen in the fact that the paths or deposits of coal-dust extended from the coal-face to the shaft, and, if explosions were initiated in coal-dust at the coal-face, propagation to the shafts was the terrible probability. He (Mr. Stuart) hoped that the gravity of the subject would be accepted as cause for discussion at such length, and he would add his appreciation of the many important observations recorded in the *Report*, which he thought was a valuable contribution to the subject of colliery explosions.

Mr. W. C. Blackett (Durham) wrote that, as he had had an opportunity of investigating the cause of the explosion at Urpeth colliery, he could not allow some of the speculative views thereon, which had been advanced, to pass without comment.

To anyone, who had ever had the interesting experience of an ignition of fire-damp passing over him, there should appear little difficulty in forming a conception of all that happened at Urpeth colliery, and there was little need to strain the imagination as to what took place to cause the ignition. Explosion was an

unfortunate word, which to many minds caused an impression of greater and more sudden violence than was often found to be the case. To go a step further and begin to think of detonation was worse still, and was, besides being unnecessary, quite unwarranted. Mr. Ashworth had expounded many useful views on matters akin to this in the safety of mines, but surely he could not expect many people to conceive the possibility of simultaneous detonations at long distances apart, all set up by percussive action in the elastic medium of the air in the galleries of a mine. There was not the slightest evidence of any such phenomena at Urpeth colliery. It might be here stated that a very careful examination was made of Barnes, and that Mr. Ashworth was quite mistaken in saying that the position of the body indicated instantaneous unconsciouness by percussion. The body actually indicated a typical death from carbon monoxide and that only.

It was somewhat curious to find two such well-known observers as Messrs. Ashworth and Stuart, both, from one and the same report, deriving authority to conclude in the one case that gas was the chief delinquent, and in the other that it was dust. So easy was it for one man to miss completely the meaning of another's expression that Mr. Ashworth actually took a perfectly sound remark by Mr. J. B. Atkinson to mean that "'dry' coal-dust was a controlling factor in bringing an explosion to a termination." Mr. Atkinson would doubtless correct this misapprehension, but it was not easy to believe that there was any second person who could draw out such a conclusion as this.

Digressing for a moment, it was not easy to see how Mr. A. L. Steavenson got his idea that there was no evidence of gas, nor on what grounds he so decidedly blamed the stemming. How could the stemming be so very seriously to blame when it had not been blown out, and much of it was left intact in the fore-end of both shot-holes?

The following, however, were the chief points of evidence on which to build a reasonable common-sense theory of what really happened at Urpeth:—(1) The working-places were giving off a regular supply of fire-damp, which, after the explosion, in a sluggish air-current (sufficient, however, to re-ventilate the galleries), showed a cap on the ordinary safety-lamp. (2) The ventilation in Suggett's stenton, being controlled by brattice-cloth,

would tend also to be sluggish, even before the explosion, and it was also a heavily-rising place, in which such air as could flow would find its way in and around the brattice-cloth next the floor, without complete diffusion with the lighter and warmer gases above. (3) There was, as was common in the Busty seam, a good deal of coal-dust, which, although perhaps not so fine and impalpable as that on a haulage-road, was yet quite capable of being momentarily raised in the air by such a sudden shock as that from a shot. (4) Two shots had been fired, one before the other. Both shots had so acted as to shoot down only the back-end of the coal, leaving portions of the fore-end undisturbed with the stemming (of coal) still in the holes. (5) A careful examination suggested that neither shot had enough work to do, and that the second had probably had much less to do than the first shot.

Neither the deputy nor the hewer were very careful men, otherwise the shot-holes would not have been stemmed with small coal when clay was lying within a very few feet, nor would the shot-box have contained more than the statutory quantity of explosive. Whether from such men a very careful examination for gas was to be expected was very doubtful; but, at any rate, the first shot was fired without inflaming any gas. It was still more doubtful that any examination was ever made for the second shot; but, in any case, a merely perfunctory examination could easily have failed to notice what ought to have been seen.

The first shot would certainly raise some dust, and it was well known what a mixture of dust with an otherwise harmless amount of fire-damp could do. But also it must be remembered that the first shot would not only stir up the dust, but would develop, in a close place, a good deal of heat, and Dr. P. P. Bedson had shown what a small amount of heat could effect in the way of occluding gases from comparatively large surfaces of exposed coal. There might, therefore, in addition to dust, be even more gas for the second shot to fire into than was the case with the first, and there was also very probably more heat than work from the explosion. A more or less gentle ignition then took place, which at first probably wavered and flickered about in the upper part of the gallery, heating and expanding the atmosphere and also distilling out more gas from the raised dust. Such a heating

and expansion of air could not take place in a cul-de-sac without causing an outward current and pressure. The increased current stirred up more dust, and the increasing pressure of slightly gas-laden air produced more favourable conditions for combustion. At last, the volume of expansion became greater, and developed sufficient pressure to knock out critical props and allow falls to take place, which subsequently lent a false appearance of great violence. And finally, the outrushing volume passed the water, and ignition ceased for want of dust and prepared conditions.

In the meantime, so much dust had been raised and so small was the oxygen-supply, that very incomplete combustion took place, and a thick dense pall of black smoke filled the atmosphere, parts of which even then had begun to cool. As it cooled, the contents of the galleries contracted and a slow returning current was set up, depositing oily dust upon the outbye side of props and other objects. Also it began to "rain" a black oily soot, which covered all horizontal surfaces with a thick blanket, serving to indicate how plentiful had been the fuel and how inadequate the combustion.

The men were all killed by the deadly carbon monoxide; but so fleeting had been the contact of heat that their hair and woollen clothing barely indicated a crisp scorching, and not even this in the case of Barnes.

What need was there of any less simple theory than this? Presumably no one would pause to doubt that they were dealing only with a mixture of air and gas: there would be greatly varying conditions of ignition or explosion, depending entirely on the relative admixture of the gases and also on whether diffusion was more or less complete. Thus, where pure undiffused gas came into contact with air, only the point of mixture would burn; and it could only be simultaneous where complete diffusion had taken place more or less uniformly throughout, and then the violence would depend on the relative mixture. It was quite conceivable that a correct molecular mixture of gas and air could fill a mine, and be simultaneously exploded or even detonated on the application of flame; but such a condition was inconceivable with dust. An ignition of dust and air must always be a travelling phenomenon, varying in intensity at its flame-point with the more or less favourable condition prepared by the pioneering air-rush. Here, the dust raised and the pressure

would be scant and small, giving feeble but still fire-bearing results. There, the mixture of dust and heated air-pressure would be more chemically correct, and violence great enough to justify the use of the term explosion would result. It was conceivable, too, that a coal-dust ignition could be so prolonged that at one end of its path expansion and progression could be taking place; while, at the other, the exact contrary might obtain, as also a "back-lash," which might even be fed by an out-flow from the return-airways and produce some of those contradictory evidences of force-direction which had so often puzzled observers.

No mechanical mixture of dust and air could ever act like the diffused molecular conditions of gases.

To talk therefore of detonating a mixture of dust and air would be almost as vain as to speak of detonating a train of gunpowder.

DR. P. PHILLIPS BEDSON (Armstrong College, Newcastle-upon-Tyne) wrote that, with respect to the analyses of the samples of coal-dusts submitted to him by Mr. J. B. Atkinson, it might be pointed out that the ratio of fixed carbon to volatile matter afforded information as to the extent of coking. For a given coal, this ratio varied within certain limits and was more or less characteristic of the coal in question. When the coal was strongly heated or partly burnt, the ratio would alter by reason of the diminution of the volatile matter, so that the ratio gave an indication of the extent to which the coal of a given sample had been heated. Taking the analyses of coals from the Busty seam,* this ratio of fixed carbon to volatile matter varied from 2·39 to 2·77, and the average of five samples was 2·56. Analyses made in the Armstrong College laboratories gave for the bright coal from the Busty seam 2·03; and for the dust from the screens of Birtley colliery, kindly supplied to the writer by Mr. Philip Kirkup, this ratio was 2·17, whilst for dant, from the same seam, the ratio was 4·96. It might be taken, therefore, that the ratio in question for coal from the Busty seam would vary between the limits of 2·03 and 2·56. Bearing this in mind, it would be noted that the analyses of the samples collected by Mr. Atkinson showed that the dust had been more or less

* *Analyses of British Coals and Coke, and the Characteristics of the Chief Coal-seams worked in the British Isles*, 1907, page 25.

A LOCKING HOOK FOR SINKING PURPOSES.

By HENRY LOUIS.

In shaft-sinking, it is very usual to work with two kibbles, which are alternately attached to the winding-rope, so that one may be filled at the shaft-bottom, whilst the other is being emptied at bank. The kibbles are attached to the rope by means of an ordinary spring hook, and it may occasionally happen that a kibble drops off the hook, through the kibble being badly loaded, the spring being weak, or the kibble badly put on, etc. An accident of this kind caused the writer to devise the hook which forms the subject of the present note.

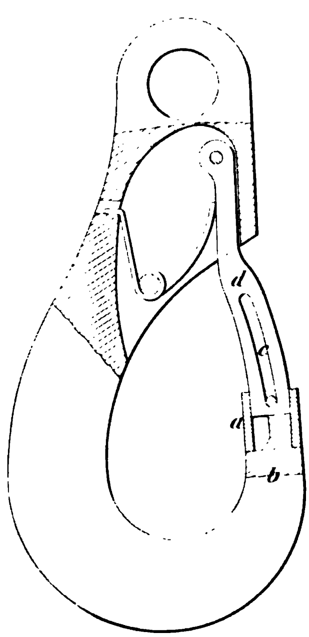

Fig. 1.– Safety Hook. Scale, 4 Inches to 1 Inch.

A sliding ferrule, *a*, fitted to the tongue of the hook, is prevented from dropping off it by a pin passing through a slot, *c*, in the tongue, *d*. To open the hook, the ferrule is simply pushed upward as far as it will go, and when the hook is closed, the ferrule slides down over the point, *b*, of the hook, thus firmly locking the hook, which cannot be opened without sliding up the ferrule. The safety of the hook is thus independent of the spring, which may, indeed, be dispensed with if desired, although the writer prefers to retain it. Several of these locking hooks have been made and used, and are found to answer perfectly the object for which they were designed.

Mr. H. W. Hughes (Dudley, Worcestershire) wrote that the movement referred to by Prof. Louis was undoubtedly superior

to the ordinary spring, but it was by no means novel, as the sliding ferrule had been used for several years at the Baggeridge sinking, in South Staffordshire. Continual trouble being experienced by the breakage of the ordinary spring, or by its losing temper and becoming weak, the breakage was overcome by arranging the spring as shown in fig. 2. The small projection, A, prevented the spring from being dashed against the back of the hook, but it did not remove the disadvantage caused by the loss of elasticity in the steel. In order to prevent any possibility of the

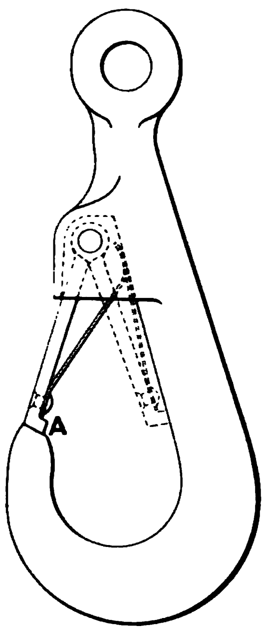

Fig. 2.—Spring Hook.
Scale, 6 Inches to 1 Inch.

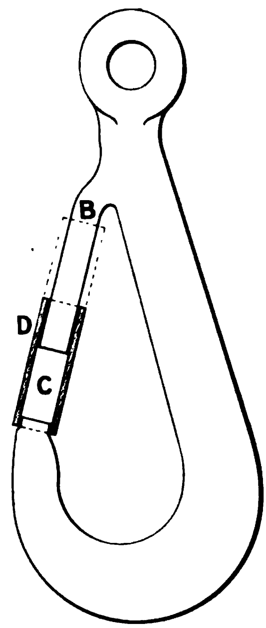

Fig. 3.—Safety Hook.
Scale, 6 Inches to 1 Inch.

bow of the kibble dropping off the hook, Mr. Ivor Morgan, enginewright at Baggeridge colliery, arranged for the hinge, B, of the spring-portion to be welded to the top, as shown in fig. 3, leaving a sufficient space, C, between the point of the hook and the slide-piece, D, for the bow to pass through: this was sealed during all ordinary operations by the sliding ferrule, D, which always dropped unless it was deliberately propped up. Experience had proved that the hook was more safe, when the spring was entirely dispensed with.

Prof. LOUIS wrote that he was interested in Mr. Hughes' remarks; and the fact that both Mr. Hughes and himself had been led to adopt the sliding ferrule for preventing the class of accident referred to, seemed to show that the idea was quite sound, although they had not both hit upon identically the same way of carrying out the idea. It seemed to him that Mr. Hughes' method might be better for very large hooks, and his own for smaller ones. He would like to add that, although the general design of the hook that he had described was his own, it was only right to point out that the details had been worked out by Messrs. Joseph Cook, Sons & Company, Limited.

Mr. J. G. WEEKS moved a vote of thanks to Prof. Louis for his description of a safety-appliance.

Mr. A. L. STEAVENSON seconded the resolution, which was approved.

Mr. R. CREMER described the "Wolf-Bohres Electric Safety-lamp," as follows:—

WOLF-BOHRES ELECTRIC SAFETY-LAMP.

By R. CREMER.

The Wolf-Bohres electric safety-lamp, fitted with an osram lamp made especially for the purpose, is supplied according to two designs: one arranged to throw the light downward and the other upward. The osram glow lamp will give an equal light, while using slightly more than half the electrical energy required by a carbon lamp. The lamp is fitted with a single-cell accumulator, affording the advantage of a considerable reduction of the weight of the lamp and a more simple treatment of the accumulator. The average length of burning of a 2 volts osram lamp is 600 to 800 hours, against scarcely 100 hours for a 4 volts carbon lamp.

The lamp is fixed in a strong air-tight glass globe, mounted on the top of, or below, the accumulator, and accessible from all sides. The pure air enclosed between the glass globe and the glow lamp becomes heated by the burning lamp, and its pressure is thereby increased. Should the glass globe be smashed and the glow lamp injured, then the expanded heated air drives back the outer air of the mine, and will at the same time rush into the vacuum of the lamp, causing the filament of the lamp to be instantaneously destroyed. The circuit is thereby interrupted, and the glow lamp extinguished, before an explosive atmosphere has time to enter and to reach the light. Numerous tests made in explosible mixtures have shown that this lamp is safe, under all known conditions prevailing in mines.

The lamp is closed by means of a magnetic lock, which prevents unlawful opening and thereby producing sparks at the contacts. The top and bottom parts of the lamp are connected by slots and projections; and electric contact is formed by sliding two broad spring plates over the contact bridges of the accumulator. The contacts consist of a metal alloy, on which diluted sulphuric acid has a small and slow effect. The opening of the lamp is effected by withdrawing the iron-locking bolt by means of a magnet.

The single-cell accumulator, enclosed in a celluloid case, fits loosely into the lamp-body, and can be readily removed and replaced. The leads to the contact-pieces are bedded-in and are acid proof. The filling opening is fitted with a three-chambered screw-closing device, allowing any gas developed to escape, but preventing any acid from flowing out when the lamp is held in a slanting position.

The rectangular lamp-body, made of tinned sheet-steel, with round metal ends, is covered with an acid-proof paint.

The accumulator feeds the glow lamp, giving 1½ to 2 candle-power, for 12 hours. The accumulator is connected up to a simple charging-device by plugs.

The weight of the lamp, ready for use, is 4 pounds, and the height is 10½ inches.

Mr. J. G. Weeks, in proposing a vote of thanks to Mr. Cremer for his paper, stated that the Wolf-Bohres lamp was a step in the right direction, if it would burn 12 hours, although the weight was somewhat excessive. It was unfortunate that an electric lamp would not detect the presence of gas.

Mr. M. Walton Brown seconded the resolution which was cordially approved.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,
HELD AT DUNSTON-UPON-TYNE, AUGUST 29TH, 1907.

FERRO-CONCRETE WORK AT DUNSTON-UPON-TYNE.

In addition to a warehouse built on the Mouchel-Hennebique system of ferro-concrete near the northern bank of the river

FIG. 1.—FERRO-CONCRETE GRANARY.

Tyne, at Newcastle, the Co-operative Wholesale Society, Limited, has adopted the same method of construction for the execution

of other interesting examples of architectural and engineering work in the district.

The most important of these buildings is erected at Dunston, and measures 155 feet in length, 110 feet in width, and 94 feet in height to the uttermost level. This structure (fig. 1) comprises a granary divided into fifty-six bins or silos for the storage of grain, and a grain-cleaning house surmounted by a tower containing a tank for water-sprinkling apparatus, while the main roof of the cleaning-house forms a water-storage tank, 4 feet deep. The building stands upon a continuous foundation-slab of ferro-concrete, connecting the heads of numerous piles

FIG. 2.—DISCHARGE-OUTLETS OF HOPPERS.

driven deep into the mud, which extends downward for the depth of about 80 feet. Each of the piles carries part of the load, the remaining part of the total load being transmitted to the surface of the ground by the general foundation-slab. This system of foundation work has been employed with great success in dealing with unstable soils, and it has proved very satisfactory at Dunston under the enormous weight of the building and its contents.

Each of the silos in the granary department measures 43 feet in height by 14 feet square, and has a storage-capacity of more than 600 quarters of grain, the entire series providing a total capacity of 35,000 quarters. Each silo is carried on ferro-concrete beams and columns beneath the partition-walls (fig. 2), an arrangement

which results in much economy of space and affords ample space for the conveyor-bands by which the grain is transported from the discharge-outlets of the hoppers at the bottom of the silos.

In the cleaning department, the engine-house occupies a space extending to a height of two stories, its roof being formed of arched beams with a clear span of 36 feet, which carry the columns affording intermediate support for all the floors above. These beams also carry a travelling crane of 10 tons and a traveller-beam, which is hung from brackets at one side of the engine-house.

To provide for the accommodation of vessels bringing wheat to the granary, a ferro-concrete wharf, partly in the form of a

FIG. 3.—FERRO-CONCRETE JETTY.

jetty, had been constructed to a length of about 420 feet. This structure consists of Hennebique piles continued in the form of columns, securely braced in every direction and connected by a continuous decking-slab. This jetty has been extended for a further length of 330 feet, thereby affording further accommodation for loading and discharging vessels, and, at the same time, opening the way for the reclamation of the area between the river-bank and the jetty. The extension (fig. 3), completed a few months ago, comprises twenty-one bays, each founded on six Mouchel hollow-diaphragm piles, having an average length of 45 feet, and built monolithic, with a ferro-concrete superstructure consisting of columns, walings, bracing and a continuous decking.

A novel type of granary-building, 176 feet long, 92 feet wide and 86 feet high above quay-level, is being erected on a reclaimed site, behind the original jetty. The main part of this structure will consist of six cylindrical grain silos, each measuring 70 feet in height from the top to the bottom-outlets, and 46 feet in internal diameter, and providing a total storage-capacity of nearly 60,000 quarters of wheat. These silos are arranged in two rows of three, and at each end there will be a rectangular wing containing smaller silos and accommodation for grain-cleaning machinery. This building is founded upon a number of Mouchel hollow-diaphragm ferro-concrete piles driven into the mud, and connected by beams of the same material below floor level, while a second series

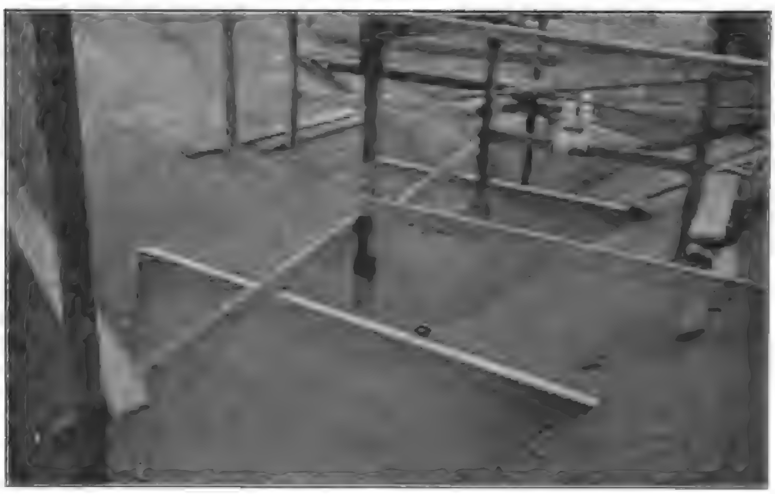

FIG. 4.—INTERIOR OF CIRCULAR GRANARY, IN COURSE OF ERECTION, SHOWING DISCHARGE-OUTLETS.

of beams in the floor-system will constitute additional bracing. The large silos are to be supported by columns and beams disposed so as to give the maximum amount of space for the conveyor-bands, and the other parts of the structure will be framed in accordance with the methods usually adopted in the Mouchel-Hennebique system of monolithic construction. A general floor will be carried above all the silos; and, as this is to be covered by a flat roof, an upper storey of considerable area will be placed at disposal. The structure is a novelty in the way of granary-design, and its bold lines are distinctly favourable to effective and striking architectural treatment.

Good progress had already been made in the foundation-work; and, judging from the extremely variable character of the subsoil, as evidenced by the experience of set obtained for piles quite near one to the other, it would be a very hazardous undertaking to attempt the erection of so large and heavy a building, on so treacherous a site, without the aid of ferro-concrete.

The erection of a soap-factory has been commenced on the existing bank of the river behind the jetty-extension; but, in course of time, the area of water and mud between these two structures will be reclaimed. This building will be a three-storey structure, 265 feet long and 120 feet wide. It is founded upon Mouchel ferro-concrete piles, and built throughout of ferro-concrete on the Hennebique system.

On completion, the establishment of the Co-operative Wholesale Society, Limited, at Dunston, will comprise an interesting series of structures representing the most recent types of ferro-concrete construction.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION MEETING,

HELD AT FELLING, AUGUST 31ST, 1907.

The members were present at the annual inspection of the Felling Colliery Corps (No. 6 District) of the St. John Ambulance Brigade, and at a demonstration of rescue-apparatus, for use in mines, in a model gallery. They afterwards inspected the electric pumping plant at Tyne Main colliery.

ELECTRIC PUMP AT TYNE MAIN COLLIERY.

The Hutton seam, in Gateshead Park royalty, leased by Messrs. John Bowes & Partners, Limited, is now practically exhausted and standing full of water; and probably the High Main seam was also worked, but there are no plans or records of the workings in this seam in existence. It is now proposed to work the seams lying between the High Main seam and the Hutton seam to the Felling shaft; but, before this can be accomplished, the water standing in the Old Fold and other shafts must be pumped out. As the diameter of the Old Fold pit is only 8 feet, it was decided that an electrically-driven pump was the only feasible means of draining the shafts. The total depth to the Hutton seam is 564 feet. The shaft was originally divided by a brattice, which is being taken out as the water is reduced.

A Mather-and-Platt high-lift turbine-pump has been put in, driven by electrical power. This pump consists of eight sets of vanes or impellers; each set runs in its own chamber, upon a common shaft, and the delivery-pressure of the water varies directly with the number of chambers used. Thus, if an ordinary single pump can deliver water against a head of 30 feet, the addition of another chamber will give a final delivery-head of 60 feet, and so on. The water enters axially into the

revolving wheel, traverses the curved internal passages between the vanes, and is discharged tangentially at the periphery into a stationary guide-ring of special construction. It is then conveyed to the annular chamber in the body of the pump, where the velocity-head imparted to the water by the wheel is converted into pressure-head. From this chamber, the water is finally discharged into the second and subsequent chambers, and then into the rising main. The stationary guide-ring is fixed concentric with the revolving vanes, and, owing to its design, enables the conversion of velocity-head into pressure-head to be carried out in a much more perfect manner than is possible in the case of any other centrifugal pump; and, consequently, the possible height of lift and the efficiency of the pump are greatly increased. The motor driving the pump has an output of 170 horsepower, when running off a circuit at a pressure of 440 volts and a frequency of 40 cycles per second, at a speed of about 1,200 revolutions per minute. The motor is of the short-circuited rotor-type, the rotor being carried on ball-bearings. The motor is completely enclosed, and the stator is air-jacketed. The motor is started, from the surface, by means of an automatic transformer-starter of the oil-cooled type. The switch controlling the transformer is also oil-immersed.

The pump is designed to raise 500 gallons per minute against a total head of 565 feet. At the present time, with a less head, about 800 gallons per minute are being delivered. The level of the water is now 216 feet below the surface, and when the pump commenced it was 122 feet.

The crab and jack-winch is also driven by an electric motor of 15 horsepower.

The current is supplied by The County of Durham Electrical Power Distribution Company, Limited.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN ST. MARGARET'S HALL, DUNFERMLINE, AUGUST 24TH, 1907.

DR. ROBERT THOMAS MOORE, PRESIDENT, IN THE CHAIR.

The minutes of the last two General Meetings were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. WILLIAM GRAHAM, Beechbank Cottages, Harthill.
Mr. ALEXANDER HILL, Largoward, St. Andrews.
Mr. WILLIAM M. KILPATRICK, Wilchris Cottage, Larkhall.
Mr. RANKIN KENNEDY M'ALLISTER, Townholm Engine-works, Kilmarnock.
Mr. JAMES SOMERVILLE, Climpy Colliery, Forth.
Mr. WILLIAM WILSON, Beechbank Cottages, Harthill.

ASSOCIATE MEMBER—

Mr. GEORGE MURDOCH, Technical School, Coatbridge.

ASSOCIATE—

Mr. JAMES W. TWEEDIE, Earnock Colliery, Burnbank.

DISCUSSION OF MR. A. HANLEY'S PAPER ON "THE HANLEY CAGE GUARDIAN."*

Mr. JAMES BLACK (Airdrie) wrote that the principal object of the Hanley cage guardian was to arrest the cage in the event of a broken winding-rope. The Royal Commission on Accidents in Mines in 1886 considered this subject, and reported that none of the safety catches, then in use, formed an adequate safeguard against breakage of the winding-rope.† Had the stage been yet reached, when the possibility of accident, due to the premature action of the safety catch, was less than that due to fracture of the winding-rope? That problem remained to be solved. Per-

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 165.

† *Final Report of H.M. Commissioners appointed to Inquire into Accidents in Mines*, 1886 [C.—4699], page 109.

sonally, he did not advocate the general use of safety catches, as at present constructed. In Scotland, where the shafts were principally rectangular in shape and fitted with wood guides, safety catches were not to be recommended, because the buntons and guides were not designed to arrest a descending load weighing, say, 5 or 10 tons. If the use of safety catches became general, even wire-rope guides would require to be strengthened, so as to ensure that they would not be found wanting when occasion demanded. This, however, would be a comparatively easy matter. The Hanley cage guardian was undoubtedly an ingenious and simple appliance, and he believed that it was the best cage arrester at the present time. It was a strong point in its favour that it did not grip falsely on the guides, even although the cage was rested on shuts at the surface; and by limiting the bind, which the appliance could apply to the guide-rope, injury to the latter was reduced to a minimum.

The PRESIDENT (Dr. R. T. Moore) said that the appliance described in Mr. Hanley's paper was very ingenious. He believed that its use would be more widespread in England, where rope-guides were more largely adopted than in Scotland. The guardian appeared to meet all requirements, it caught the rope firmly, which was a great advantage, while it also served to steady the cage. One naturally did not get many opportunities of testing inventions of this type; and, of course, in the absence of practical tests, it was difficult to form an opinion as to whether they would be in a position to do everything that their inventor expected them to do.

Mr. ALFRED H. BENNETT (Bristol) wrote that the Hanley cage guardian had been used at one of his pits which was equipped with wire-rope guides. This colliery had since been closed; and, in consequence, the guardian was not now in use. Experiments had been made with the guardian by dropping the cage a short distance in the headgear: the results were satisfactory so far as they went, as the guardian exercised a good grip and arrested the cage almost immediately. It was, of course, almost impossible to test this guardian under working conditions, as nobody would like to let a cage fall, when travelling at full speed, for the purpose of an experiment. The appliance was satisfactory, so far as it had been tested.

Mr. J. Fox Tallis (Ebbw Vale) wrote that, many years ago, there was much opposition and prejudice against the detachment-hook, which was looked upon as a remedy worse than the disease; but they now knew that that hook had rendered valuable service on many occasions. Recalling this, he was determined to regard Mr. Hanley's apparatus without prejudice, believing that it was the colliery manager's duty to give full consideration to any suggestion having for its object safety of working; and accordingly he had the cage guardian tested. Girders were placed across the top of the pit, and in the first instance a drop was given of 5 feet 1½ inches: the apparatus did not grip; secondly, a drop of 5 feet 9 inches was given, and it still refused to grip. Then a trial was made at the pit-bottom, and, with a fall of 8 feet 3 inches, there was a slight grip. Next a fall of 36 feet was tried; but there was no grip, and the cage fell to the bottom. Another trial was made with a fall of 36 feet, and a perfect grip took place after the cage had travelled 19 feet down the guides. On the whole, he was not satisfied with the apparatus, and perhaps Mr. Hanley would be able to suggest improvements. The apparatus had shown that it would work; but the question was, would it always work when required?

The discussion was then closed, and a hearty vote of thanks was awarded to Mr. Hanley for his paper.

DISCUSSION OF MR. JOHN F. K. BROWN'S PAPER ON "A STRETCHER FOR USE IN MINES."*

Mr. J. F. K. Brown wrote that a mistake had been made in the drawing (plate iv.†) of the stretcher, as the rope-support, from the centre of the stretcher to the bogie-standards, had been omitted. A stretcher had been made at the Hamilton Palace colliery, but it differed slightly from the proposed stretcher described in his paper. Another main band, *aa* (fig. 1, plate iv.) had been added, midway between the bands already in use and exactly similar to them. One of the end-pieces, *bb*, had been lengthened, and was now about 4 feet long. The object of these changes was to

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 162.

† *Ibid.*, page 162.

enable a slightly injured man to be supported in a sitting position inside a hutch, without the necessity of knocking out the hutch-ends, and at the same time to obtain the easy swinging motion that the stretcher was designed to afford. The caps for the bogie-standards had been dispensed with, partly owing to their weight, and partly because it was found to be just as efficient simply to tie the hooks round the standards. The weight of the stretcher, as now designed, was 9¾ pounds, and it could be folded for carrying in a bag 18 inches long and 10 inches wide. The cost would be slightly less than £2. Fortunately, the stretcher had not, so far, been tested by actually removing injured men; but so far as could be seen it would satisfactorily answer its purpose, being capable of use as an ordinary stretcher, or on a hutch, with or without the ends knocked out, or on a wooden bogie, the standards of which varied from 2 to 4 feet apart. The motion, while in it, was easy and comfortable. He suggested the use of a brattice-board, 6 feet long, placed along the stretcher (the end-pieces being dispensed with), in cases where the back was injured, as there certainly was a tendency to press the back, when lying in certain positions.

The PRESIDENT (Dr. R. T. Moore) said that the arrangement described by Mr. Brown would, no doubt, be useful in cases of accident. It was awkward to convey a man, who had been injured, to the pit-bottom, and any arrangement, that could be fixed inside a hutch, was well worthy of trial.

The further discussion was adjourned.

Mr. JAMES BAIN's paper on "Rescue-apparatus for Use in Mines" was read as follows:—

RESCUE-APPARATUS FOR USE IN MINES.

BY JAMES BAIN.

The attention of the members is directed to the following abstract of a Report on Rescue-apparatus,* of a Committee appointed by the Fife and Clackmannan Coal-owners Association.

After discussion and deliberation, the Committee have come to the following conclusions: (1) That a central station, equipped with a certain number of sets (say, twenty) of apparatus ready for use in case of emergency, is necessary for Fife, and that it should be in telephonic communication with every colliery. The Committee suggest that its position should be at Cowdenbeath, as being the most central situation. (2) That a certain number of sets of apparatus (say not less than five) should be kept ready at every colliery. (3) That at least twenty men in every colliery, including all the officials who know the mine, should be instructed in the construction and use of the apparatus. (4) That an intelligent man should have the care of the central station, and be capable of instructing the men in the use of the apparatus and keeping the apparatus in order. (5) That the apparatus designed by Mr. Garforth† is the best suited for our mines, being lighter, smaller and more flexible than any other inspected by the Committee.

(1).—The central station would consist of an office for the use of the superintendent; store for the storing of apparatus; reception-room for accommodating men who have come from a distance; a bath-room and water-closet; workshops to be used for the repair and charging of the apparatus; engineroom for the gas-engine or oil-engine necessary for driving a dynamo, for lighting the gallery and building, and charging the portable lamps, and also for driving the fan for exhausting from the furnace, and filling the experimental gallery with smoke and other noxious gases.

The station should be built in the form of a hollow square, the offices mentioned forming two sides, and the gallery forming the other two sides, a verandah running round and acting as a shelter for those who are watching the experiments.

The gallery would be constructed with windows in such a position, that the men who are being trained would always be within sight of those outside, who are watching. There would be numerous doors opening outwards, so that if a man turned ill or collapsed, he could be got out to the fresh air at once. The first part of the gallery, called by Mr. Garforth "the nursery,"‡ would

* *Report to the Fife and Clackmannan Coal-owners Association by a Committee appointed to make Enquiries regarding Rescue-apparatus for use in Mines*, September, 1906.

† "A New Apparatus for Rescue-work in Mines," by Mr. W. E. Garforth, *Trans. Inst. M. E.*, 1906, vol. xxxi., page 625.

‡ "Experimental Gallery at Altofts Collieries," *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 205.

be made without any obstructions, and have a level floor and high roof, so that the men could walk about without any trouble for some time after getting inside, and get accustomed to the conditions of the atmosphere without having to exert themselves. The other part of the gallery would be constructed to resemble, as nearly as possible, the conditions of a mine after an explosion. Thus, by setting up broken timber and laying down stones, and erecting various designs of barriers; by putting a partition in the gallery with communicating doors, and having the different parts of the gallery named; by having sets of printed instructions handed to the men before going into the gallery, and in making the experiments, under the conditions named, in a foul atmosphere, a very hard task could be set, and both the apparatus and the men would be thoroughly tested for the work of rescue.

The Committee think it necessary that at least twenty sets of apparatus should be kept at the central station, as well as a sufficient stock of caustic potash and oxygen to last at least 24 hours, as by that time it would be possible to get a fresh supply from the central stores. Included in the apparatus at the central station would be a supply of specially-made stretchers for use in damaged workings and roads, as the ordinary stretcher is quite unsuitable for this purpose. There would also be a supply of all kinds of ambulance-material specially suitable for use in cases of burning, and for neutralizing the effect of bad gases.

The Committee desire to point out the necessity of a central experimenting-station as being the most important item in the whole arrangements. Such a building will be necessary for testing and repairing the different apparatus, and also for training the men before they are set to the real work of rescue. The Committee consider that it would be a very risky business to send into an injurious atmosphere men who had not been thoroughly trained and accustomed to the use of the apparatus, and with apparatus in which they had not the utmost confidence, and which had not been thoroughly tested by themselves. The Committee are of the opinion, that every man, however willing he might be to join in the rescue-work, might not be fit to undergo the strain of mental and physical exertion required to make a capable rescuer, and they would suggest that, not only for the man's own good, but for the safety of his comrades and for the protection of the employer, so far as his physical condition is concerned, he should have to pass a medical examination.

The Committee estimate the cost of a central station, with experimental gallery, to be about £1,200 exclusive of apparatus, and that it would take from £250 to £300 per annum for upkeep.

(2).—The Committee think it desirable that at least five sets of apparatus should be kept at every colliery, so that, in case of a disaster, a rescue-party could be got together at once, and would lose no time in getting to the scene of the fire or explosion in the hope of saving life, restoring ventilation, or repairing damage to enable an inspection to be made, and doing everything possible until assistance arrived from a neighbouring colliery, or additional apparatus was sent from the central station. Besides being of advantage for the above purposes, the Committee think that the apparatus would be of great benefit in giving confidence to a rescue-party in cases where the ventilation was not entirely destroyed, but in such a condition that men could not leave the main air-current without risk.

(3).—The Committee consider that twenty men at least should be trained in connection with each colliery, and that the more trained the better, for

several reasons. In the case of a local accident, the men who have a knowledge of the workings and on the spot can be utilized at once; if the accident is of an extensive nature, the colliery corps, with their special knowledge, would be available to take charge of the parties sent from the other collieries. It is probable that a number of the trained men may be involved in the accident at the colliery, and thus reduce the number otherwise available. By having a large number of trained men, less difficulty would be experienced in getting together and forming a rescue-party, and as time is of the utmost importance, trained men should always be available. In addition, each rescue-party should consist of five persons, one to have charge of the other four, whose only duty would be to direct the operations.

(4).—The Committee would suggest that the person in charge of the station should be an intelligent and handy man, and capable of doing any little repair to the apparatus. He should also be acquainted with underground workings, so that he might thoroughly understand what is required of the apparatus, and know the danger that would attend anyone who was sent out with defective apparatus. The Committee would further suggest that the man in charge should keep a set of books, recording each man's name, the colliery to which he belongs, and the dates when he made experiments; also that each apparatus, whether at the central station or the collieries, should be numbered, and that the date when the apparatus was tested (which test should be at least once in 3 months) and the result of the test should be recorded in a book.

(5).—Mr. Garforth is still improving his apparatus, not having made two sets alike, but always making the last an improvement on the previous one. In the Committee's opinion the Meyer apparatus is the next best, but it is very much heavier, more rigid, and not so handy, and occupies more space than Mr. Garforth's.

The most serious defect in all the apparatus that Committee have examined is that the men forming a rescue-party cannot communicate with each other, except by signals, such as sounding the motor-horn or waving the electric lamp carried by the man at his belt, but we believe some instrument, such as a horn attached to the mouth-piece or some other means, may be invented to allow the men to communicate with each other more readily.

Although the Committee have stated their views regarding the number of sets of apparatus which they consider should be kept at the central station and the collieries, their suggestion should only be put in force when the whole installation is completed, and they think that too many sets should not be purchased meantime, as from what they have observed it is evident that the apparatus is being improved upon rapidly, especially since the Courrières disaster. They are of opinion, however, that the coal-owners should put up the central station with an experimental gallery, and order a few sets of Mr. Garforth's apparatus so as to get a beginning made with the work, as it is probable that it will very shortly be made compulsory by law to have such an apparatus and station, apart altogether from the question being considered from the humane point of view.

The Committee desire to point out that, while the central station suggested for Fife at Cowdenbeath would not be suitable for general purposes for those members who reside in Clackmannanshire, it would be advantageous for those

members to co-operate in the suggested scheme, and thereby enable them to have their colliery apparatus tested and repaired, and also to have the use of the station for the instruction of volunteers, whom they may elect to send for training.

The Royal Commission on Mines, reporting* on the use of breathing appliances in rescue-work, etc., state that the matter is ripe for further development, and that the necessary steps towards a systematic use of the appliances should be taken by the mine-owners without delay; and they recommend that the most efficient and economical way of making provision for a sufficient supply of rescue-apparatus and for the necessary training and practice of men in their use would be by the establishment of central rescue-stations, that is, the establishment of stations at central points for the joint use of several neighbouring collieries or a group of collieries, where apparatus could be stored (supplemented, where circumstances made it necessary, by apparatus at the separate collieries), an experimental gallery provided, and men carefully instructed and trained.

It is most desirable that uniformity of action in regard to this matter should prevail in Scotland, and that the apparatus adopted and training agreed upon should be uniform throughout the respective districts; and, with this end in view, the writer ventures to express the opinion that it would be well for the other districts to form Committees to enquire into this subject, and either homologate the report and suggestions made by the Committee of the Fife and Clackmannan Coal-owners Association, or endeavour to arrange for a joint scheme, whereby uniformity may be attained.

Mr. W. D. Lloyd, manager of Altofts colliery, gave a demonstration of the use of the Weg apparatus.†

ADDITIONAL RULES.

The Secretary, on behalf of the Council, gave notice of motion for an addition to the rules providing facilities for the affiliation of societies of mining students to the Institute.

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* *First Report of the Royal Commission on Mines*, 1907 [Cd. 3548], paragraphs 20 to 24, pages 11 to 13.

† "A New Apparatus for Rescue-work in Mines," by Mr. W. E. Garforth, *Trans. Inst. M. E.*, 1906, vol. xxxi., page 625.

THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE INSTITUTE OF MINING ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE UNIVERSITY, BIRMINGHAM, OCTOBER 14TH, 1907.

MR. F. A. GRAYSTON, RETIRING-PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen, who had been duly nominated, were elected:—

MEMBERS –

Mr. F. HOWARD BRIGGS, Manor Court Road, Stockingford.
Mr. L. T. LINLEY, Lansdown Villa, Nuneaton.

ASSOCIATE MEMBERS—

Mr. AJIT MOHAN SEN, The University, Birmingham.
Mr. WALTER TEBBS WALLIS, Mitcheldean, Gloucestershire.

ELECTION OF OFFICERS, 1907-1908.

The SCRUTINEERS reported that the following officers had been elected:—

PRESIDENT: Mr. ALEXANDER SMITH.
VICE-PRESIDENT: Mr. A. W. GRAZEBROOK.

NEW MEMBERS OF COUNCIL:

Mr. W. CHARLTON.	Mr. HUGH JOHNSTONE.	Mr. W. H. WHITEHOUSE.
Mr. G. A. HURST.	Mr. G. W. WARING.	

The Annual Report of the Council and the Treasurer's Account were read and adopted as follows:—

ANNUAL REPORT OF THE COUNCIL, 1906-1907.

The Council report that, during the past year, 11 members have been elected, 4 members have resigned, 11 have been struck off for non-payment of subscriptions, and 1 has died, leaving the total number at 175.

Dr. THE TREASURER IN ACCOUNT WITH THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE INSTITUTE OF MINING ENGINEERS, Cr.
FOR THE YEAR ENDING JULY 31ST, 1907.

	£	s.	d.					£	s.	d.
1906.				The Institution of Mining Engineers—						
Oct. 22.—Balance in bank	201	13	2	Current year	£126	7	11			
Subscriptions received	194	16	0	Arrears	58	1	8			
Bank-interest	4	10	3					184	9	7
				Rent, rates and cleaning of room				20	0	0
				Secretary's and reporter's salaries				50	0	0
				Printing, stationery, etc.				11	8	6
				Expenses of Walsall meeting				0	18	8
				Framing portraits				1	10	0
				Postages, telegrams, auditors' and Secretary's expenses ...				12	12	5
				Balance in bank				120	0	3
	£400	19	5					£400	19	5

BALANCE-SHEET, 1907.

Liabilities.	£	s.	d.	Assets.	£	s.	d.
Nil				Subscriptions due	196	12	6
Balance	316	12	9	Balance in bank	120	0	3
	£316	12	9		£316	12	9

Examined and found correct,

WILLIAM H. WHITEHOUSE,
T. J. DAVIES,
Auditors.

October 14th, 1907.

This balance is exclusive of considerably more than £100 worth of property, for which no credit is taken.

The receipts for the year are more than usual, but the expenditure has been considerably increased owing to the payment of all arrears to The Institution of Mining Engineers. The arrears of subscription are very large, and amount to £196 12s. 6d.

An interesting "Inaugural Address" was delivered by the President (Mr. F. A. Grayston) and the following papers have been read:—

"The Hanley Cage Guardian." By Mr. A. Hanley.
"The Hidden Coal-fields of the Midlands." By Prof. C. Lapworth.
"Boilers for Colliery Purposes." By Mr. F. C. Swallow.
"Walsall Corporation Electrical Supply." By Mr. S. L. Thacker.

The important paper by Prof. Lapworth produced a valuable discussion, in which Mr. Daniel Jones and many members of the Institute took part, and this elicited a comprehensive reply from Prof. Lapworth.

There have been five general meetings (including one at Walsall, where the members enjoyed a visit to the power-station and sub-stations), eight Council meetings, and one excursion to the Birmingham Corporation electric generating-station in Summer Lane.

The Institute's property (with the exception of certain *Transactions*, necessary for the Secretary) has been removed to the Mining Department of the University, at Bournebrook, in accordance with the arrangements made early in the year. It will be classified and kept in order under the charge of Prof. R. A. S. Redmayne, and will be available to the members for inspection and reference together with that belonging to the University.

The Institution of Mining Engineers makes very satisfactory progress, and the membership is increasing. Sixty-eight papers have been read during the past year. A committee has been appointed, consisting of two members and the Secretary of each Institute, to report upon "the status and qualifications of membership of The Institution of Mining Engineers."

The thanks of the Institute are due, and are hereby tendered, to the University of Birmingham for providing rooms for the use of the Institute.

The President (Mr. Alexander Smith) delivered the following address:—

PRESIDENTIAL ADDRESS.

By ALEXANDER SMITH, M.Inst.C.E.

I have to thank you most sincerely for the honour which you have conferred upon me by electing me your President for the ensuing year. I appreciate it the more as I have been Secretary for 32 years, and therefore no one can have had a closer association with this Institute or be more anxious for its welfare.

It had been my intention to have given a condensed history of the Institute, and this I hope to do at a later period, but I think that there are more important matters which demand attention. I would just refer in passing to the fact that the Institute, which was founded in 1866 by the late Mr. Henry Johnson calling his mining friends together, was granted a certificate of incorporation in 1867 as The Association of Mine Agents of South Staffordshire and East Worcestershire. In 1869, however, the Association was converted into a scientific institution. Since this period, it can be fairly claimed that, in addition to furthering generally its objects, which are the discussion of the means for "the ventilation of coal and other mines, the winning and working of collieries and mines, the prevention of accidents, and the advancement of the sciences of mining and engineering generally," several important matters have originated with and have been advanced by the Institute.

The idea of a trial-sinking for the now important Sandwell Park colliery was first introduced at the Annual Meeting held at Dudley on February 7th 1870 by the late Mr. Henry Johnson, and the success of the undertaking conclusively proved the existence of the Thick coal-seam beyond the eastern boundary-fault of the South Staffordshire coal-field—in the same manner as the recent Baggeridge sinking on Lord Dudley's estate, the work of Messrs. G. H. Claughton, J. Hughes and H. W. Hughes (father and son), and Prof. C. Lapworth, all members of this Institute, has settled the doubt as to the existence of coal beyond the western boundary.

This Institute induced the authorities of Mason College to found the first chair of mining, and a prominent member was appointed professor. Although this was not a success, owing to the want of sufficient support, we have kept in close touch with Birmingham University, and have done all that we could in furthering the present Mining Department, which bids fair to be one of the best, if not the best, mining school in the world. It must be gratifying to you that during the past year measures have been taken to strengthen our association with the University Mining School, which must tend to mutual advantage.

The bearing of these undertakings upon the subject which I specially wish to consider in this address, on the future prospects of Birmingham and the adjoining Midlands with regard to fuel, will be obvious. The wealth, the prosperity, or as a matter of fact the very existence, of a nation, comes from the land either through agriculture or mining; and it is clear that this country is dependent mainly upon the latter, as we cannot feed ourselves and have to look to our colonies and foreign countries for much of our food-supply. Coal, therefore, is in a sense the essence and foundation of all industries and the essential for all advancement. In other words, heat, speaking physically and of course not spiritually, is the first great cause and the origin of all energy. We look on electricity, which has developed so enormously of late years, as an attribute of heat; but whether some day it may be found to be something behind heat, and the foundation of matter, must be left to great minds capable of dealing with such a subject.

The old outcry of the exhaustion of the coal-supplies has greatly subsided, and the recent Royal Commission has done much to allay anxiety. Fortunately two members of this Institute, Prof. C. Lapworth and Mr. Arthur Sopwith, were elected on the commission, proving certainly very active and useful, more especially with regard to the Midland districts. Although much important information is obtained by such commissions, only a condensation of it comes out in the reports, and the conclusions arrived at are rightly very guarded. It was consequently very gratifying when Prof. C. Lapworth consented to give his able paper upon "The Hidden Coal-fields of the Midlands."* Prof. Lapworth is so conversant, by his study and research, with this

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 26.

district, that his connection with the commission would only as it were refurbish his knowledge, and it was kind of him, while the matter was fresh, to provide us with his masterly paper. In addition, the retiring-President, Mr. F. A. Grayston, gave, in his address, some excellent practical information, not only with regard to the geology, but concerning the practical results of mining explorations in the Warwickshire district.* This Institute has given much attention to an important factor arising from these extensions of the old coal-field, which is the difficulty of extracting the Thick coal-seam at great depths, and a committee was appointed to consider the subject and get information upon it.

Taking first the geological point of view, we glean very much satisfaction from the conclusions of Prof. Lapworth and other scientific men, who have spent so much time, trouble and ability in studying the coal-fields, both exposed and hidden, of the Midlands. Speaking generally, it is assumed that there are 8,000 square miles of productive coal-measures, after giving credit for probable denudation, and that of this about 1,700 square miles make up the visible coal-fields, large portions of which, with a little of the hidden, have been worked. The estimate of the geological members of the Royal Commission on Coal-supplies is that 5,500 square miles of this area remain yet to be tested, but they give the warning that only perhaps 3,000 square miles of it lies within 4,000 feet from the surface, leaving the other as beyond the depth-limit, which it is presumed it would not be technically possible or profitable to go. This deals with the larger Midland area; but coming nearer home, and taking the two basins which more immediately concern us, we have the Wolverhampton basin or the district beyond the western boundary-fault of the South Staffordshire coal-field—and the Birmingham basin at the eastern side of the South Staffordshire coal-field (plate i.). Owing to the success of the Baggeridge boring and sinking before mentioned, the Thick coal-seam has been found, and, so far as explored, appears to extend under the Red Rocks in an even and satisfactory manner. As to the whole of this basin, extending between the South Staffordshire and Shropshire coal-fields, there seems to be a slight difference of opinion, for that eminent geologist, Mr. Daniel Jones, holds that there has been extensive denudation of the

* "Presidential Address," by Mr. F. A. Grayston, *Trans. Inst. M. E.*, 1906, vol. xxxii., page 312.

productive coal-seams at the time of the formation of the Symon fault, whilst Prof. Lapworth is more sanguine and thinks that this theory is far from being established. No doubt much of this area is uncertain and can only be proved by borings, but the result at Baggeridge is promising, and we certainly hope that similar results will be achieved in the future. Coming now to the Birmingham basin, the Sandwell Park and Hamstead collieries are conclusive evidence of the existence of the Thick coal-seam over the eastern boundary-fault and of the probability of the continuation of the measures under the whole of the basin, till they join the Warwickshire coal-field, excepting where, if Prof. E. Hull's theory be correct, the Cambro-Silurian ridge or ridges exist.

Mr. Grayston, in his address last year, dealt very fully with the northern part of this district, and I may be permitted to add some information as to the southern part, with which I am largely concerned. The Warwickshire coal-field is a very old one, and there is an account-book in Mr. Newdigate's possession at Arbury, Nuneaton, showing that coals were wrought by his ancestors as far back as 1603. And Mr. Matthias Dunn stated that the first steam-engine for mining purposes was used at Griff colliery about the year 1700.* So far as this portion of the coal-field is concerned, simply the fringe of it has been worked, and it is only of late years that pits have been sunk in the deep under the Red Rocks, adjoining the visible coal-field. These are the Tunnel, Newdigate and Arley collieries. The eastern boundary of this part is formed by the outcrop of the Coal-measures on a roll of the Cambrian formation, where there are considerable intrusions of igneous rocks, and the western portion may be limited for a time by a fault which runs north and south from Kingsbury, through Nether Whitacre, Shustoke and Maxtoke to Berkswell, where it has become dislocated and is shown farther east but still running north and south through Kenilworth to Warwick. This fault does not terminate the coal-field, which no doubt extends away to Staffordshire and Birmingham. It is doubtful whether the extent or the nature of this fault has been tested anywhere, excepting at the Park collieries, so that it is as yet an unknown quantity: it is probably a downthrow to the west of considerable extent,

* *A Treatise on the Winning and Working of Collieries*, by Mr. Matthias Dunn, 1848, page 22; and second edition, 1852, page 11.

where the measures are rising towards it at Arley. There is a downthrow fault to the west running across the coal-field from Maxtoke through Arley to between Oldbury and Monks Park Wood, the direction being north-east, and it is supposed to be a continuous fault. There is no doubt that it has much disturbed the Coal-measures, as is experienced in the new pits at Arley. The dip of the mine is in a south-westerly direction; and at Tunnel pits, underneath the Midland-railway tunnel, the bottom of the basin seems to have been reached, as there is a gradual rise to the Arley pits, which seems to increase much to the west. At the Tunnel pits is probably the most prolific section of coal-seams to be found in the district, as these aggregate 60 feet in thickness, 36 feet of which, at least, will be commercially workable. It seems likely that the fault, mentioned as being near the Arley pits, must have to some extent raised the measures on its eastern side and that they will dip again to the west before the long north-and-south fault is reached. This conclusion suggests itself, because farther south the measures dip continuously from the outcrop, so that the first coal-seams are 1,470 feet deep at Newdigate colliery and 1,920 feet at the Packington bore-hole, which is close to the long north-and-south fault, where, from other indications, the measures would be expected to be rising to the west. It is evident from this that, although the fault may have been sufficiently indicated for the surface-mapping, by the Geological Survey, there is uncertainty as to its effects in the deep. A very important point is that, to the extreme south, the Coal-measures do not die out so soon as geologists have anticipated, and that they will be found for a considerable distance south of Coventry. There is evidently faith in this theory, as a large colliery is now in course of development at Binley.

The coal-seams, at the northern portion between Nuneaton and Arley, are fairly divided with intermediate strata, so that they are convenient to work; but farther south the upper seams come close together, and near the outcrop and where they are upon an incline they are worked on the Warwickshire system, that is with several faces going together, one immediately behind the other, with a level-heading connecting each with the lower portion, in which are the inclines.

Newdigate colliery is the deepest in the district, and there the Two-yards, Bare, Ryder, Ell and Slate coal-seams come to-

gether, as one seam, and are 24 feet in total thickness, corresponding with the Thick coal-seam at Sandwell Park and Hamstead collieries.

The question of working this Thick coal-seam at great depths, especially where it is fairly level, is a serious one, because of the crush and the liability to spontaneous combustion, and the large amount of coal that has to be permanently left. This recalls the calamity at Hamstead colliery, when the weight so dislocated the ribs between the main roads in the shaft-pillar, that the air got into them and induced fire which led to the closing of the pits, and the subsequent re-opening from a new inset in the Brooch coal and rock, higher up the shaft. The Institute, recognizing the importance of the subject, two years ago appointed a committee to consider it, when a series of questions were formulated and sent out, but I am sorry to say met with little response.

Mr. J. T. Browne, the manager of Newdigate colliery, read a paper upon the Thick coal-seam of Warwickshire at the June Meeting of The Institution of Mining Engineers in London. After describing the seams and difficulties with gob-fires, he went very clearly into the question of the best mode of working this Thick coal-seam, and favoured the Warwickshire system of taking out the whole of the seam together, excepting the necessary partings, in three or four faces, one following the other, and accomplishing it by a system of fore-winning and retreating, so that the goaf and water were left behind in the separate panels or sides of work, and gob-fires were less liable to occur and more easily dealt with. In the deep portions of South Staffordshire, the coal-seam has been worked on the rib-and-pillar-system, and the crushing and bumps as described by Mr. F. G. Meachem in his several papers* have been something alarming; as a result, only about half the coal in the seam has been, or probably ever will be obtained. Mr. Browne's paper gave rise to an animated and interesting discussion, which was contributed to almost entirely by Warwickshire members. Several prominent men, including two of H.M. inspectors of mines, expressed regret that there were no other South Staffordshire engineers present, and that more time could not be given to so important a subject. I consequently hope that in the immediate future we may get a joint

* "Notes on an Earth Explosion or 'Bump' at Hamstead Colliery," by Mr. F. G. Meachem, *Trans. Inst. M. E.*, 1893, vol. v., page 381; and "Bumps and Outbursts of Coal," by Mr. F. G. Meachem, *Ibid.*, 1897, vol. xii., page 612.

paper from Staffordshire and Warwickshire members, and that this vital point to the successful winning of thick seams at a great depth may be thoroughly thrashed out.

As before mentioned, in accordance with the views of Prof. Lapworth and other geologists, about 2,500 square miles of the untested area in the Midlands may well lie beyond the limit-depth of 4,000 feet. In reviewing the evidence before the last Royal Commission on Coal-supplies, the main consensus of opinion was that the engineering difficulties of exceeding this limit could be dealt with: German engineers were particularly strong on this point, and they were equally sanguine of overcoming the physical difficulties of crush and increased temperature.

With regard to the main subject of increased temperature, the formerly accepted increase of 1° Fahr. for each 60 feet of depth is found not to be reliable. It is to be regretted that when these tests have been made they have seldom been of an exhaustive or thorough character. Fortunately, with regard to the deep Thick coal-seam we have some data very carefully taken by Dr. J. S. Haldane and Mr. F. G. Meachem in their paper* read before this Institute in 1898, and in a further paper† by Mr. Meachem in 1903. The subject is so fully considered and the conclusions are so clear that it is unnecessary to say more than that the heat of the rocks will probably not exceed 1° Fahr. for every 120 feet in depth, or half the old estimate; and that, so far as both engineering and physical difficulties are concerned, they will be easily surmounted when the time comes.

The financial point of view is of course a serious one, and with increased depth and greater capital-outlay, the natural conclusion is that the coal will be more expensive to get; but, with the advance of scientific methods, many costs will be reduced, and with economies similar to those of late years fuel may be looked upon as a more valuable commodity and fetch a comparatively higher price. The economies must not be confined to manufacturers, but must be carried out in domestic pursuits, so that there will be much less smoke, and our large

* "Observations on the Relation of Underground Temperature and Spontaneous Fires in the Coal to Oxidation and to the Causes which favor it," by Messrs. John S. Haldane and F. G. Meachem, *Trans. Inst. M. E.*, 1898, vol. xvi., page 457.

† "Underground Temperatures," by Mr. F. G. Meachem, *Ibid.*, 1903, vol. xxv., page 267.

towns will become cleaner and clearer and more like those of our Continental neighbours.

In economizing the consumption of fuel, even mining engineers are now making great strides. There is room for this when it is considered that even modern pumping-engines consume from 6 to 7 pounds of coal per horsepower per hour, and winding-engines 10 to 11 pounds. Mr. J. A. Longden considers that including drawing men and timber, and maintaining steam day and night, the consumption is 21·4 pounds per horsepower per hour. One pound of coal should generate heat sufficient to maintain 5 horsepower per hour. If the process of generating electrical energy is followed through from the heat-units of the coal by means of the steam-boiler and engine, only about 7 per cent. is realized; and the gas-engine with the most modern producers is certainly an improvement, but there is still a very big margin. I look for the time when there will be a more direct production of electrical or some other form of energy, and a fuller realization of the 14,000 heat-units contained in 1 pound of coal. I consider that I am justified in this when one contemplates the transition from the old wooden walls of England to the massive battleships of the present day and their multitudinous machinery, from the sailing vessel to the quick-floating palaces such as the *Lusitania*, from the old horse-gin to the modern colliery-plant raising 5,000 tons per day, to the way in which cars can run with mechanical power at great speed on common roads, to communications through telephones over hundreds of miles, or by electrical waves without wires.

Again, look at the results of necessity and competition, the electric light, which was to snuff out gas, has led to the incandescent light and other improvements that have wonderfully stimulated the latter industry; the gas-engine has brought out vast improvements and economies in the steam-engine which it was going to annihilate; and electricity has rendered the transmission of power so easy that everything seems possible. Bear in mind, too, that this has mostly been accomplished by self-trained men, who have not had the advantages of modern technical schools or universities. With the education to be obtained at the Birmingham University, with such a great scientist as Sir Oliver Lodge at its head, and similar institutions, men will be provided to continue and to further advance the sciences, and as results are now being enjoyed that a few years ago were looked upon as im-

possible, so future generations will conquer all we now consider difficulties and look upon many of our notions as obsolete and antiquated.

Coming now to the duration of the coal-fields, the Royal Commission on Coal-supplies, with all the valuable information that they had accumulated, would not prophesy; but they were of opinion that the present rate of output would only slowly increase for a time and then probably decrease, because of the difficulties of getting, and the growing economies. Consequently, their figures show a duration, at the present rate, of 440 years for the proved coal-fields and of 600 years, if the unproved areas are included. The proved coal-fields of South Staffordshire and Warwickshire, at the present rate of working and with most liberal allowances in every way, including faults and barriers, will afford a supply for over 200 years; but if the estimates of the available coal in the unproved coal-fields, given by the Geological Committee of the Royal Commission, are taken, the period is extended to 1,100 years. The Committee say "available coal," but it is not clear whether they have made any allowance for faults, barriers, etc., and if not this would reduce the time by about 200 years. The areas below the limit-depth of 4,000 feet and the probable extension on the south of the Warwickshire coal-field are not taken into consideration, so that I am strongly of opinion that with these, with increased yield, and with the economies and advancement of science, there will be a much longer life than is anticipated. When, however, the period of exhaustion is approaching, no doubt the tides or winds will be harnessed, the sun's rays concentrated or heat generated in some other way, and there need be no concern as there is a hopeful and long future for posterity. The Creator who has provided the bountiful supplies, and the genius to develop them in the past, will preside over the future, therefore no thought need be taken for the morrow.

Prof. R. A. S. Redmayne, in proposing a vote of thanks to the President, observed that one of the pleasing features of his excellent address was its cheerful optimism, with which he was entirely in accord, and of which they had too little in the past. The President had stated the theoretical heat in coal, he had shown what had been achieved, and had given useful advice as to where economy might be effected. He was much obliged to the

President for his kindly reference to the Mining School at the University. It was fitting that the Institute and the Mining Department should work together; and he hoped that many of his students would become eminent members of the Institute.

Mr. H. C. PEAKE, in seconding the motion, agreed with Prof. Redmayne that the optimism of the President's address was most welcome, as much more of that spirit should be shown than had obtained of late years. During the twenty-five years that he had known Mr. Smith, the output of the South Staffordshire portion of their district had remained stationary. The coal-field, as a whole, had not made much progress, but Cannock Chase had been further developed and now maintained the output by supplying the deficiency of the Thick coal area, which had been, to some extent, exhausted. The President had considered the two coal-fields in their relation to each other; this, he (Mr. Peake) thought, was perfectly right, as they were no doubt one area originally. He thought that the more the University Mining School and the Institute worked together the better it would be for both.

Mr. ALEXANDER SMITH acknowledged the vote of thanks.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

Held in the Wood Memorial Hall, Newcastle-upon-Tyne, October 12th, 1907.

Mr. J. H. MERIVALE, President, in the Chair.

The Secretary read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on August 17th, September 28th and that day.

The following gentlemen were elected, having been previously nominated:—

Members—

Mr. William Bell, Colliery Manager, Plashetts Coal and Coke Company, Plashetts, S.O., Northumberland.

Mr. Walter James Browning, General Manager, Mazapil Copper Company, Limited, Concepcion del Oro, Estado de Zacatecas, Mexico.

Mr. Robert William Church, Mining Engineer, Dragon Villa, Durham.

Mr. George Alexander Curry, Colliery Manager, Thornley House, Thornley, S.O., County Durham.

Mr. Robert William Glass, Colliery Manager, Axwell Park Colliery, Swalwell, S.O., County Durham.

Mr. Henry Malkin Hance, Mining Engineer, Nagpur, Central Provinces, India.

Mr. Howell Arthur Hopwood, Mining Engineer, General Manager, Bandgermassin Coal and Diamond Fields, Dutch Borneo.

Mr. Isaac John Hopwood, General Manager, Sungei Tiram Tin-mines, Johore, care of Post Office, Singapore.

Mr. Matthew Robson Kirby, Mining and Mechanical Engineer, Holywell Hall, Durham.

Mr. George Augustus Longbotham, Mechanical Engineer, Ings Foundry, Wakefield.

Mr. John Straker Nesbit, Colliery Manager, Marley Hill Colliery, Swalwell, S.O., County Durham.

Mr. Thomas Elliot Parrington, Mining Engineer, Hill House, Monkwearmouth, Sunderland.

Mr. Frank Reed, Inspecting Engineer of Mines, Mines Department, Wellington, New Zealand.

Mr. PERCY EDMUND SMALLWOOD, Colliery Manager, Garesfield Colliery, High Spen, Newcastle-upon-Tyne.

Mr. FRANCIS JOSEPH STEPHENS, Superintendent, Blackwell's Development Corporation, Limited, Knaben Grube, Fjotland, *via* Flekkefjord, Norway.

Mr. FRANK REGINALD WATTS, Nut and Bolt Works Manager, Cleveland House, North Shields.

Mr. MATTHEW BROWN WILD, Colliery Engineer, 37, Arthur Road, Erdington, Birmingham.

ASSOCIATE MEMBERS—

Mr. NOEL COLLINGWOOD DICKSON BORRADAILE, Motor Mine, Gatooma, Rhodesia, South Africa.

Mr. EDWARD OTTO FORSTER BROWN, Springfort, Stoke Bishop, Bristol.

ASSOCIATES—

Mr. DANIEL JOHN DAVIES, Deputy, Corrimal, near Sydney, New South Wales, Australia.

Mr. THOMAS EMMERSON, Surveyor, Lucas Street, New Silksworth, Sunderland.

Mr. ROBERT GRAHAM, Deputy Overman, 31, Railway Terrace, Willington, S.O., County Durham.

Mr. JOHN SWANSTONE JOBLING, Miner, 10, Langley Street, Langley Park, Durham.

Mr. EDWARD MIDDLEMASS LEWISS, Mechanical Draughtsman, 3, Eighth Row, Ashington, Morpeth.

Mr. GEORGE AUSTIN SEPTIMUS ROGERS, Mechanical and Electrical Engineer, Greenhead Terrace, Chopwell, Ebchester, S.O., County Durham.

Mr. JOSEPH SNAITH, Colliery Under-manager, South Pontop Colliery, Annfield Plain, S.O., County Durham.

STUDENTS—

Mr. SAMUEL BAILEY COXON, Mining Student, Prior House, Corbridge, S.O., Northumberland.

Mr. ALBERT ERNEST FOWLER, Mining Student, Usworth Villa, Washington, Station, S.O., County Durham.

Mr. HENRY HEPBURN, Mining Student, Greenhead Terrace, Chopwell, Ebchester, S.O., County Durham.

Mr. HENRY MOORE HUDSPETH, Apprentice Mining Engineer, Willington, S.O., County Durham.

The following paper by Messrs. P. PHILLIPS BEDSON and HENRY WIDDAS on "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air" was read as follows:—

EXPERIMENTS ILLUSTRATIVE OF THE INFLAMMABILITY OF MIXTURES OF COAL-DUST AND AIR: PART II.

By P. PHILLIPS BEDSON, D.Sc., and HENRY WIDDAS, B.Sc.

In a paper* recently read before this Institution, a form of apparatus was described by which the inflammability of mixtures of coal-dust and air could be studied, and on that occasion it was shown that whilst a small gas-flame would ignite a cloud of coal-dust, it failed to inflame a mixture either of charcoal-dust or of dant and air. Substituting for the gas-flame that of a Bunsen burner, or, better still, a Mecker burner, in both of which a flame of much higher temperature is produced than in a luminous gas jet, it is possible to procure an inflammation of charcoal and of dant. This shows that the temperature of ignition of such mixtures is much above that of an ordinary bituminous coal-dust. But, even with a luminous flame, a difference between coal-dusts from different coals is shown by the amount of dust required to produce an inflammation. Thus, it has been found that with brown coal 0·1 to 0·2 gramme (1½ to 3 grains) suffices to produce an ignition, whereas with Busty seam bright coal 0·2 gramme (3 grains) and with Barnsley cannel and Hutton seam coal, 0·8 gramme (12 grains) of each are needed to give a distinct inflammation.

With the object of comparing the relative inflammability of coal-dusts of different origins, the authors determined to replace the coal-gas flame in the apparatus, described in the former paper,† by a coil of platinum wire suspended in the box from the upper opening. Since by heating the wire, by passing through it an electric current, a considerable range of temperature could be secured; and further by employing the

* "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air," by Messrs. P. Phillips Bedson and Henry Widdas, *Trans. Inst. M. E.*, 1906, vol. xxxii., page 529.

† *Ibid.*, vol. xxxii., page 530.

same wire and of a given length, and measuring the current used to cause the wire to glow, a measurement is got which gives an indication of the temperature attained in a particular experiment. Thus, the number of ampères used to ignite equal weights of coal-dust serves to indicate the relative inflammability of dusts of different sources. For example, with 1 gramme (15·4 grains) of dust in each instance, the currents recorded in Table I. were required with the apparatus used to produce inflammation.

TABLE I.—CURRENT, IN AMPÈRES, TO PRODUCE IGNITION.

Dusts.	Ampères.
Brown coal	10·5
Busty seam, bright coal	11·5
Hutton seam, coal	11·5
Lycopodium	11·5
Brockwell seam, cannel	12·5
Harvey seam, splint	17·0

With dust from anthracite, and also from dant, no ignition was obtained with a current of 17 ampères; and it was not deemed desirable to use a greater current, for fear of fusing the wire.

The dusts employed in these experiments were made by grinding the coal and sifting through a No. 100 sieve, and were simply air-dried. The effect of drying the coal-dust after grinding was evidently to lower the temperature of ignition, as shown by the somewhat smaller current required in each case (Table II.).

TABLE II.—CURRENT, IN AMPÈRES, TO PRODUCE IGNITION OF DRIED DUSTS.

Dried Dusts	Ampères.
Brown coal	9·8 to 10·0
Busty seam, bright coal	11·0 to 11·5
Hutton seam, coal	11·0 to 11·5
Brockwell seam, cannel	11·5 to 12·6
Harvey seam, splint	13·0 to 15·0

The influence of moisture was further tested by exposing the dust for a lengthened period to moist air: the dust for this purpose was placed on a shallow tray, under a bell-jar standing over a dish of water. Brown coal-dust, after 72 hours' exposure to moist air, and Hutton seam coal-dust after an exposure of 96 hours, required currents of 12·2 and 13·5 ampères, respectively, for their ignition: representing an increase of approximately 2 ampères above that required for the dried materials. In the case of the Hutton seam dust, this exposure would represent an increase in the proportion of moisture

from 1·5 to 2·12 per cent. In another set of experiments, freshly-ground dust was made into a paste with water, and was then allowed to dry by exposure to the air; on the sixth day it was dry enough to form a cloud in the apparatus, and was then found to contain 3·1 per cent. of moisture. This air-dried coal required 13·5 ampères for its inflammation, the freshly-ground coal requiring 12·5 ampères. The coal was again made into a paste with water, and the paste allowed to dry spontaneously in the air; on the fourth day it was so damp that it did not form a cloud, and then was found to contain 13·72 per cent. of moisture; on the fifth day it formed a cloud which ignited with 13·8 ampères: the dust then contained 3·77 per cent. of moisture. After 8 days' drying, the dust was found to contain 1·78 per cent. of moisture, and required 13·8 ampères for its ignition.

It is evident that, to prevent the ignition of an inflammable coal-dust, it must be so damp that it cannot be blown into a cloud by a jet of air, and further that an increase in the proportion of moisture has a tendency to raise the temperature of inflammation.

A dust becomes less sensitive to ignition by lengthened exposure to the air, as is shown by the fact that a freshly-ground dust, which at first ignited with 12·5 ampères, after 17 days' exposure to the air, required 14 ampères for its ignition.

The effect of mixing incombustible solid matter with coal-dust is not only to retard the inflammation, but also to raise the temperature to which the mixture must be heated in order to produce an ignition. In support of this, the following experiment may be cited:—One gramme (15·4 grains) of brown coal-dust was ignited with 12·5 ampères; a mixture of 1 gramme (15·4 grains) of this dust with 1 gramme (15·4 grains) of dry sand gave an inflammation four times out of six, with a current of 13 ampères; with a mixture of 1 gramme (15·4 grains) of coal to 1½ grammes (23·1 grains) of sand and a current of 13·5 ampères, ignition occurred three times out of four; whereas by increasing the proportion of sand to twice that of the coal 15·5 ampères were required to attain inflammation.

Using coal from the Hutton seam in a similar manner, the following results were observed:—1 gramme (15·4 grains) of coal alone, required 12·5 ampères; 1 gramme (15·4 grains) of coal with 0·5 gramme (7·7 grains) of sand, required 13 ampères;

1 gramme (15·4 grains) of coal with 1 gramme (15·4 grains) of sand, required 14 ampères; 1 gramme (15·4 grains) of coal with 1·5 grammes (23·1 grains) of sand, with 14 ampères, gave a feeble inflammation; 1 gramme (15·4 grains) of coal with 3 grammes (46·3 grains) of sand, with 15 ampères, gave practically no inflammation.

A few experiments have been tried to show the influence of charcoal, when mixed with an inflammable coal-dust. A mixture of 1 gramme (15·4 grains) of charcoal and 1·5 grammes (23·1 grains) of Hutton seam coal-dust was found not to be ignited, even with a current of 16 ampères. On the other hand, charcoal, when moistened with petrol and then exposed to the air until apparently dry, carried enough petrol to make it easily inflammable. In fact, 1·5 grammes (23·1 grains) of charcoal, so treated, gave a decidedly explosive inflammation with 15 ampères. On standing exposed to the air for two days, the charcoal ceased to act in this way.

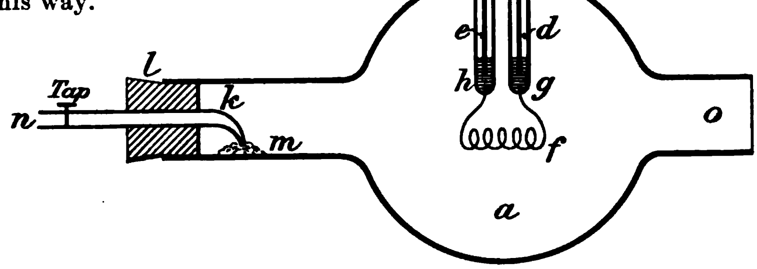

FIG. 1.—EXPLOSIONS VESSEL. SCALE, 4 INCHES TO 1 INCH.

Whilst these experiments may be regarded as affording distinct evidence of the difference exhibited by coal-dusts in the formation of inflammable mixtures with air, they also show something as to the influence of moisture, and of the deadening effect of incombustible matter and of non-volatile combustible substances; still, they leave much to be desired in the way of precision as to the result of the inflammation. This can only be gauged by the eye and registered as violent inflammation, a

slight puff or no ignition, as the case may be. An attempt has been made to gain more exact information in the following manner:—An explosions vessel, *a*, has been constructed of glass, spherical in form, and of about 2 litres (122 cubic inches) capacity. The vessel is provided with three tubulures; one, *b*, for the insertion of an indiarubber stopper, *c*, through which pass two glass tubes, *d* and *e*, and into the closed ends of these are fused the ends of a coil, *f*, of platinum wire. The tubes contain a small quantity of mercury, *g* and *h*, into which dip iron wires, by which the platinum wire can be electrically connected with the terminals, *i* and *j*, of a battery and a current passed through the platinum to raise it to the desired temperature. A second tubulure, *k*, serves for the introduction of the coal-dust, *m*, and connection, *n*, with the air-compressor. Whilst to the third tubulure, *o*, is attached the apparatus which serves to register the pressure developed by the inflammation of the dust. The apparatus employed consists of a large three-necked Wolff bottle, one opening of which is connected by tightly-fitting stoppers and glass tubing with the explosions vessel; to the second is fitted a simple gauge, consisting of a U-shaped tube, the bend of which contains coloured water, the end of the tube being sealed. In the third opening of the Wolff bottle is fitted an indiarubber stopper carrying a glass tube, to the open end of which is attached a piece of indiarubber tubing closed by a spring clip. It is evident that, by this arrangement, the sudden pressure produced by the inflammation inside the explosions vessel would make itself evident in a compression, registered by the movement of the liquid in the U tube. The extent of this movement is registered by the aid of a scale attached to the closed limb of the U tube.

Using the same weight of coal-dust, and the same current, it was found that the same coal gave quite consistent results, that was, practically the same compression. Further, the same weights of different coal-dusts gave different compressions. Thus, on using the same weight of coal-dust, and the same number of ampères for heating the platinum wire, the compressions registered would represent, on an arbitrary scale, the explosive character of the mixture of dust and air.

A number of samples of coal-dust have been examined in this way, some of these dusts representing samples collected in mines, while in other cases the dusts represent coal ground in the

laboratory. In Table III., giving these results, the former are described as natural dusts, the latter as artificial. It will be seen that the compressions registered vary from a negligible amount to 5 inches. It should be mentioned that the weight of dust used in each case was 2 grammes (30·8 grains), the air used to project the dust was under a pressure of about 8 inches of mercury, and the wire was heated by a current of 15 ampères.

TABLE III.—EXPLOSIVE CHARACTER OF DUSTS.

No. of Experiment.	Nature.	Moisture.	Volatile Matter.	Fixed Carbon.	Ash.	Ratio of Fixed Carbon to Volatile Matter.	Ratio of Fixed Carbon and Ash to Volatile Matter.	Pressure.
		Per cent.	Per cent.	Per cent.	Per cent			Inches.
1	Artificial.	14·86	45·77	35·87	3·50	0·78	0·81	—
2	,,	1·52	34·01	58·55	0·94	1·50	1·51	5
3	,,	6·08	38·22	52·85	2·85	1·38	1·46	5
4	,,	8·58	31·89	57·78	1·81	1·81	1·86	2
5	Natural.	1·07	27·49	63·72	7·72	2·32	2·59	4
6	,,	5·20	29·05	42·22	23·60	1 45	2·27	1·5
7	,,	5·01	28·38	37·08	29·60	1·30	2·35	1·5
8	,,	6·00	21·70	7·63	64·67	0·35	3·33	0
9	,,	4·14	21·31	12·06	62·55	0·56	3·50	0

NOTES: (1) ground brown coal; (2) ground coal from Hutton seam; (3) ground coal from Grey seam coal; (4) ground coal from Yard seam coal; (5) screen-dust from Busty seam; (6) dust from timber-baulks and haulage-road in Yard seam; (7) dust from stone in roof of Yard seam; (8) dust from top and bottom of timber-baulks and roof of Grey seam; and (9) dust from sides of haulage-roads and pillar-sides of Grey seam. As to the pressures, the length of the sealed limb of the U tube, above the level of the water in the tube, is 12 inches: a pressure of 5 inches, therefore, would represent a compression sufficient to reduce the volume of air to seven-twelfths of its original volume, and so on.

Further, the dusts were all such as would pass through a sieve with 100 meshes to the linear inch. It is scarcely justifiable to draw conclusions from the data (Table III.) furnished by these few experiments; still, attention may be directed to the influence of the proportion of volatile matter upon the inflammability and also upon the explosive character of the combustion. It may, however, be claimed that the method of examination affords a ready means of gaining information as to the character of a dust, and is also of service for the purposes of demonstration.

The authors hope to be able on a future occasion to lay before the members an account of further investigations on this important question, and meanwhile wish to express their thanks to the Council of the North of England Institute of Mining and Mechanical Engineers for the grant, which has enabled one of them to devote himself to the conduct of this work.

APPENDIX.

Dr. W. M. Thornton, Professor of Electrical Engineering in Armstrong College, has determined for the authors the resistance of the platinum wire, when heated with the currents used as described in the paper. From the data so provided, and by the aid of the coefficient of the increase of resistance with temperature of platinum as determined by Prof. H. L. Callendar, the temperatures of the coil of platinum wire, when heated by the electric currents, are as follows: 10 ampères correspond to 630° Cent., 12 ampères to 700° Cent., 15 ampères to 870° Cent., and 17 ampères to 970° Cent.

Mr. J. B. Atkinson (H.M. Inspector of Mines) said that the members were grateful for the data which Dr. Bedson and Mr. Widdas were collecting by means of these experiments in connection with the question of coal-dust; and, when they came to the practical question of dealing with the dangers arising from coal-dust, the results already obtained, and those which they still hoped to receive, would be of the greatest service.

Mr. W. C. Blackett (Durham), referring to No. 2 dust (Table III.), asked whether Dr. Bedson would have expected an increasing ratio of pressure, if it had already gauged 5 inches when the dust was ignited.

Prof. Henry Louis said that the experiments recorded by Messrs. Bedson and Widdas would form the basis of any future studies that might be made on the subject; and the data already collected seemed to lead to a number of valuable conclusions. They showed that roadway-dust was less dangerous than dust at the face, and that probably attention would have to be devoted almost exclusively to the dust which was being brought out with freshly hewn coals. He would like to direct the authors' attention to the state of division of the dust. He noted that all the dusts had been passed through a screen with 100 meshes per linear inch, and he was of opinion that it would be necessary to go more accurately into the question of gauge before the neces-

sary data were obtained. It would probably be found that charcoal, if excessively finely divided, would be capable of being ignited, where under ordinary conditions ordinarily fine charcoal would not ignite, and the same statement, of course, would apply to other substances. No. 5 (Table III.), a natural dust, contained a higher percentage of ash than those preceding it; it also had a much higher ratio of fixed carbon to the volatile matter, and from all previous working, as well as from other considerations, it should have been less explosive than the dust immediately preceding it, and yet the explosive power was twice as great. It was a natural dust, contrasted with artificial ones, and he would be inclined to look for the explanation of the anomaly in the fineness of the dust.

Mr. W. C. Blackett agreed that the fineness of the dust was an important consideration, and particularly the compression of the air. If the coal was reduced to very small particles it exposed comparatively a very much larger surface to be oxidized by the air, and, if the dust were submitted to a greater air-pressure, it would be more readily oxidized than at a lesser pressure. He agreed that the physical state of the dust was as important as its chemical constituents: and it was possible that an explanation of the small discrepancies in the Table might lie in the relative fineness of the dusts.

Mr. T. E. Forster (Newcastle-upon-Tyne) congratulated the authors on the results of their experiments. The question of the fineness of the dusts should be carefully noted; and particulars should be given showing the state of division of the coal. It might not be satisfactory to divide the coal into very fine dust, but it should be tested just as it was found in the mine. After all, they wanted to find out whether the dust in main roads was dangerous or not.

Dr. Bedson said, without theorizing, and only expressing his opinion, he was inclined to think that increased pressure in the glass globe would tend to increase the relative violence of the explosion. Roadway dusts were less easily inflammable, and produced smaller mechanical effects than other dusts. The fineness of the dust, was, no doubt, of very considerable importance, as well as the physical condition and the chemical composition, and he proposed, when he had the opportunity of taking up the question

of the fineness of the dusts, to submit the dusts, such as those now experimented with, to a further separation. The results obtained with No. 5 dust (Table III.) were certainly very anomalous, and the proportion of the ash was considerably higher than in the case of the artificial dusts. It was a screen-dust, and very nearly resembled No. 2 dust, obtained from the same district. Bright coal, like No. 2, was remarkable for the proportion and character of the gases enclosed in it; and the dust was specially interesting from a chemical point of view, inasmuch as it contained combustible gases which were much more readily inflammable than marsh-gas. Whether the gases contained in No. 5 coal, or the fine division of the screen-dust, afforded an explanation of its explosive character, as compared with the others in which the ratio of fixed carbon to volatile matter was much less, he could not say; no doubt it was due to the proportion as well as the nature of the volatile matter. The gases obtained from brown coal, No. 1, were very different in character and composition from those obtained from bituminous coal, and appeared to be much more readily inflammable. He did not know whether equal weights of brown coal and bituminous coal would produce exactly the same mechanical effect.

The President (Mr. J. H. Merivale), in proposing a vote of thanks to Dr. Bedson and Mr. Widdas for their paper and the interesting experiments, said that they were to be congratulated on the exceedingly effective apparatus which they had designed for the purpose of their investigations. They had designed an apparatus which was of practical service. He could speak from experience, because 25 years ago he had tried experiments on the same subject, and they were a miserable failure: partly, no doubt, owing to his want of skill, but partly also because there were not the same facilities at Armstrong College then as there were now for conducting such experiments.

The vote of thanks was heartily adopted.

Dr. John Morrow's paper on "The Strength of Cast-iron Tubbing for Deep Shafts" was read as follows:—

THE STRENGTH OF CAST-IRON TUBBING FOR DEEP SHAFTS.

By JOHN MORROW, M.Sc., D.Eng., of Armstrong College, Newcastle-upon-Tyne.

I.—Introduction.

1.—The accurate determination of the most economical form and dimensions of cast-iron cylinders, such as are used for lining deep shafts, is a matter of such great theoretical difficulty as to be, in the present state of knowledge at any rate, impossible. The best that can be done is to examine certain assumptions and to select those which, while they are useful for the purpose, are most likely to represent, at least approximately, the true state of affairs.

Much has been written on the subject, but the author is not aware of the existence of any paper giving anything like a complete statement of the problems involved. On the other hand, many theories which have been advanced are manifestly unsound, and inaccurate formulæ have been published and often accepted without criticism. Mr. Isaac Hodges* has called attention to the great disparity in the thicknesses of tubbing as calculated by the formulæ respectively due to Messrs. J. J. Atkinson, W. Galloway, G. C. Greenwell and W. Tate. The thicknesses which he himself adopted at the Methley Junction colliery were invariably greater than those given by any of these rules. Mr. H. W. G. Halbaum, and others, have also called attention to these discrepancies.

2.—It is necessary, at the outset, to define clearly the sort of structure which we propose to discuss. Actual tubbing is constructed in different ways. The chief points common to all are: the general shape is cylindrical; the tubbing is built in rings, some 2 or 3 feet in height; each ring is made up of a number of segments; and each of these segments is furnished

* "An Account of Sinking and Tubbing at Methley Junction Colliery, with a Description of a Cast-iron Dam to resist an Outburst of Water," by Mr. Isaac Hodges, *Trans. Inst. M. E.*, 1906, vol. xxxii., page 76.

with a flange running round each of its four edges, and with one or more stiffeners, parallel to each edge, intermediate between the flanges. The variable points in the design are: the flanges and intermediate stiffeners may be on the inside or on the outside of the cylindrical shell; the segments are sometimes bolted together into complete rings, and these rings may be further connected by bolts to the rings above and below them; when bolts are not used, the segments are firmly wedged together by means of wedges driven home between adjacent flanges; the segments are sometimes joined together and then turned in a lathe to ensure more accurate fitting; and the space behind the tubbing may be filled in with loose earth, or a backing may be employed of cement-concrete or other material, such as might add to the strength of the tubbing, or at least tend to prevent its collapse.

The author will always assume, unless the contrary is specifically stated, that the cross-section of the tubbing is truly circular; and also that the pressure of the water or earth on the external surface of the cylinder acts purely in a normal direction, and is of uniform intensity at all points on the circumference of any cross-section. The magnitude of the pressure is, of course, a function of the depth of the section.

Since both the vertical and horizontal joints have, under normal conditions, to transmit compressive force only, and since a departure from normal conditions (if sufficiently small) will not introduce tensile stresses, the author will assume generally that the joints are capable of transmitting stress, just as if the whole structure consisted of a single casting. When the segments are bolted together, a limited amount of tensile stress may be transmitted through the joints; but the discussion of how the transmission takes place would be long and difficult. The inability (when it exists) to transmit tensile stress ought, no doubt, to limit in some way the discussion of the resistance to collapse. Any weakness due to this cause has to be set off against the gain of stability due to the backing. A further result of this assumption is that the elasticity of the tubbing-ring may be considered to be (for small displacements) unimpaired by the joints; or rather, that the effects of the joints may be considered to be negligible.

3.—The elements of uncertainty in the problem include, in

addition to the effect of the joints between the segments of tubbing, such factors as: the lack of circularity; the rate of corrosion; the nature and amount of the external pressure; the influence of temperature-change; the unequal settlement of the curbs; and many other disturbing causes.

A large number of semi-empirical formulæ have been published at various times. They are mostly, if not invariably, based on the resistance of a cylindrical shell to compressive stresses caused by external pressure. At first sight, it would appear that such formulæ are important; but a closer investigation reveals the fact that the strength of the tubbing must depend far more upon other considerations than those upon which the theory of thin cylinders is based. It is hoped that in the present paper all the important questions are considered.

The author does not maintain that an accurate method of treatment has been discovered, or even that the theories employed are strictly applicable to the uses to which they have been put. His desire has been to bring into the field of practical mining some theories which have not been hitherto used; and, by the discussion of the applicability of these theories, to endeavour to throw some additional light on the questions concerning the sources from which cast-iron tubbing derives its strength.

4.—It has been usual to calculate the thickness, from some such formulæ as those mentioned in the last paragraph, assuming that the compressive circumferential or hoop stress is taken entirely by the cylindrical shell. The number and dimensions of the ribs appear to have been chosen arbitrarily. An accurate theory must correctly apportion the stress between the flanges, the ribs and the shell. It is frequently stated that the horizontal flanges and ribs give little or no assistance to the shell in this way. Such a statement is very different from merely saying that the stress thus borne may be neglected, as the error is on the side of safety.

In this connection, it is worth while to point out that in a segment of fairly heavy tubbing, more than one-third of the area of the face of the tubbing has behind it a thickness of metal which is greater than the nominal thickness of the shell (figs. 1 and 2, plate ii.).* The matter may be put still more forcibly, if weights instead of areas be compared. Thus, it may fre-

* *Mining*, by Prof. Arnold Lupton, 1893, page 123.

quently happen that the weight of metal having the thickness of the shell is only about one-third of the weight of the complete segment. Such considerations force the author to the conclusion that the importance which the cylindrical-shell theory has attained is quite artificial. The great sources of strength of tubbing lie, not in the shell, but in the flanges, ribs and brackets. It is in this that the tubbing problem differs so greatly from that of the boiler-flue.

5.—The function of that part of the tubbing which may be called the "plate," or "shell," is two-fold. It has to resist a portion of the hoop stress, and it has to transmit some of the external pressure to the ribs and flanges. In the former case it is subjected to compressive stresses and in the latter to bending action.

The horizontal ribs are not only stiffeners. Although this is, no doubt, their chief object, they play an important part in resisting the circumferential stresses. The formulæ for their stability is one of the novel features of this paper. The horizontal flanges perform similar duties to the ribs; but, owing to the lack of symmetry (forming the outer edges of the plate), the straining action in them is more complicated. In addition, they may be subjected to local stresses, due to the action of the wedges or bolts.

The vertical ribs and flanges are very different in their functions, and seem to be of much less importance than those which are horizontal. They transmit some of the vertical stress due to the weight of the structure; and that part of the external pressure which they receive from the shell they, in turn, transmit to the horizontal rings.

The object of the brackets is, of course, the ordinary one of increasing the lateral stability of the ribs and flanges.

6.—It is necessary, in a complete investigation, to consider a number of different ways in which the tubbing may fail. Many of these may be disposed of, once for all, as giving no trouble in practice. It is not claimed that the methods used in this paper are unimpeachable so far as mathematical accuracy is concerned; but it is hoped that when they err it is invariably on the safe side.

The customary calculation is to provide against failure under the crushing stresses, as calculated by the theory of hollow

cylindrical shells. This theory is set forth in sections 8 to 11. The resistance of a thin cylinder to collapse is dealt with in sections 15 to 19. The question is one of stability; it is associated with the elasticity, rather than with the ultimate strength, of the material.

The resistance of a circular metal ring to collapse under normal pressures is similarly considered in sections 20 and 21. The author considers this to be a sound method of calculation, from a practical point of view. When it is used, it will generally be found to be the determining factor; and, in conjunction with the formula for the bending of a metal plate, will probably suffice to complete the design.

The cylindrical surface is divided by the ribs and flanges into a number of curved plates with rectangular boundaries. The calculation of the strength of these plates, as though they were plane, is a very safe proceeding. This is done in section 22. The author, in effect, assumes that the pressure is normal to a plane surface; and, at the same time, he neglects the effect of the convexity of the plate in increasing its strength.

Section 24 deals with the stresses, in the lower rings, due to the weight of the structure.

II.—Resistance to Crushing.

7.—*Theories of Rupture.*—The greatest compressive stresses occur in the form of tangential or hoop stresses in the material of the cylinder. To calculate the thickness required to withstand these stresses safely, use can be made of a problem in the theory of elasticity, usually known as that of thick cylinders.

However, at the outset, one is confronted by an important question on which there is so far no unanimity of opinion. This difficulty—that it is not yet definitely known what it is that causes material to fracture—has an important bearing on our problem.

The matter is further complicated by the fact that the theoretical formulæ are only true, provided that the limits of elasticity are not exceeded. Indeed, when rupture is spoken of in this connection, it may be taken that, for imperfectly elastic materials such as are used in engineering constructions, one means the limit at which the material becomes damaged; and this damage may be actual fracture, excessive elongation, loss of elasticity, or some other criterion by which the value of the material may be judged. In technical works in this country

it is very generally accepted, often without question, that rupture occurs when the stress in the metal reaches some definite amount. On the other hand, there appear to be equally good reasons for the view, held by some of the most competent authorities, that the criterion of rupture is not the stress, but the tensile strain in the material. In other words, it is held that fracture occurs when the material has been stretched to the extreme limit at which it can hold together. There are still other theories. For example, Lamé supposed that rupture occurred when the tensile stress exceeded a certain limit; Coulomb assumed that the shear stress was the determining factor. Others hold that the tendency to fail is measured by the difference between the greatest and least principal stresses. Let T be the breaking stress of the material as found from tensile tests, and let E be Young's modulus. On the greatest tensile-stress theory, the tensile stress must be nowhere greater than T. On the tensile-strain hypothesis, the tensile strain must nowhere exceed $\frac{T}{E}$.

For a simple tie-bar there is no difficulty; but, in a more complex problem (such as that now under consideration), the different theories lead to different expressions for the safe load or for the thickness of metal required.

It is beyond the scope of this paper to discuss these theories. All that can be done is to find the values of the stresses and strains, and to assume that the designer wishes the greatest compressive stress limited to within a certain amount.

8.—*Thin Cylinders.*—The method of computing the strength of a thin cylinder, on the assumption that the stress is uniformly distributed, is well-known. It is given in this paragraph merely as an introduction to the more accurate solution which follows. Let p_0, r_0 be the external and p_1, r_1 the internal pressures and radii, and t (equals r_0-r_1), the thickness of metal; let pressures be taken as positive and tensions as negative quantities, and so call q the hoop compressive stress in the material. The total pressure on the outside, resolved on the diametral plane, is $2p_0r_0$ per unit length of the cylinder. Similarly the internal pressure is $2p_1r_1$, opposing the external pressure. The area of metal, in the unit-length, resisting the compressive force is $2t$; and hence the stress, q, called into play is given by:

$$2qt=2p_0r_0-2p_1r_1\text{ ; and }t=\frac{p_0r_0-p_1r_1}{q}$$

gives the necessary thickness of metal if q is not to exceed a certain limit. If there is no external pressure, p_0 is zero, and

$$t=-\frac{p_1 r_1}{q},$$

the negative sign showing that q must be negative, that is, the stress is tensile. If there is external pressure only, p_1 is zero, and

$$t=\frac{p_0 r_0}{q}.$$

9.—*Thick Cylinders.*—The stresses in a thick cylinder have been computed in various ways, but the following is the only simple method that is not open to serious objection. Let fig. 3 (plate ii.) represent a cross-section of the cylinder, and let r_1 r_0 be the internal and external radii as before. Consider a thin cylinder of the material, of internal radius r and thickness δr. It will be subjected to a pressure on both its inner and its outer surfaces; this pressure is purely normal, and is exerted by the material in contact with the surfaces of the imaginary thin cylinder. Let the pressure on the inner of these surfaces be p and that on the outer $p+\delta p$, and let pressures be spoken of as positive stresses and tensions as negative. Then, just as in the theory of thin cylinders, if the unit-length at right-angles to the plane of the diagram be considered, the total bursting pressure resolved on the diametral plane is $2pr$; and that external to the imaginary elemental cylinder, similarly resolved, is $2\ (p+\delta p)\ (r+\delta r)$. Also, if q be the hoop stress (being positive when it is a pressure), the total force resisting compression in the elemental ring is $2q\delta r$ (since $2\delta r$ is the area of material cut by any diametral plane). Equating, just as in the thin-cylinder problem, it is found that:

$$2\,(p+\delta p)\ (r+\delta r)-2pr=2q\delta r\text{; or}$$

$$p\delta r+r\delta p+\delta r\delta p-q\delta r=0.$$

Further, since δr and δp are each very small quantities their product, $\delta r\delta p$, may be neglected, as being very small indeed compared with the other terms in the equation. Omitting this term and dividing throughout by δr, it follows, when δr is taken very small, that:

$$p+r\frac{dp}{dr}=q \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

In this equation, the values of p and q depend, of course, on the chosen value for r. That is, they vary from point to point in the material of the thick cylinder: p is the radial pressure, q is

the hoop pressure; and each is measured on unit-area. There is no stress at right-angles to the plane of the figure, that is, parallel to the axis. The dimensions in this direction are, however, altered.

Let fig. 4 (plate ii.) be an enlargement of the small shaded area in fig. 3. It represents a prism of material, originally of unit-length, at right angles to the paper, subjected to compressive stresses p and q as shown. Its length is slightly increased by these forces, and the increase is obviously proportional to $p+q$. Now, if a plane-section of the cylinder is to remain plane when the pressure is applied, the displacement, parallel to the axis, of each particle of material in the plane must be the same. That is, $p+q$ must be constant over the cross-section.

This is the assumption on which the theory is based. It is a reasonable assumption, compatible with the conditions of the problem, and thus differs from the assumptions made in the other theories proposed for thick cylinders which are still set forth in many text-books. Since $p+q$ is constant, let it be written as $2a$, where a is a constant as yet unknown

$$p+q=2a \quad \ldots \ldots \ldots \quad (2)$$

Using this to eliminate q from equation (1) then:

$$p+r\frac{dp}{dr}=2a-p; \text{ or}$$

$$\frac{dp}{dr}=\frac{2a}{r}-\frac{2p}{r} \quad \ldots \ldots \ldots \quad (3)$$

The solution of this equation is

$$p=a+\frac{b}{r^2} \quad \ldots \ldots \ldots \quad (4)$$

as may be readily seen by inserting this value of p in equation (3), and so obtaining

$$\frac{d}{dr}\left(a+\frac{b}{r^2}\right)=\frac{2a}{r}-\frac{2}{r}\left(a+\frac{b}{r^2}\right); \text{ or}$$

$$-\frac{2b}{r^3}=\frac{2a}{r}-\frac{2a}{r}-\frac{2b}{r^3}$$

which is true. Here, b is the constant of integration. It must be determined later from the special conditions of the problem. Using equation (4) with equation (2), it follows that

$$q=a-\frac{b}{r^2} \quad \ldots \ldots \ldots \quad (5)$$

These, then, are the equations which give, in the general case, the values of the radial pressure p and the hoop pressure q at any distance, r, from the axis. But these stresses cannot be numerically determined until the values of a and b are found.

10.—Let the values of the constants a and b be found for the case which corresponds most closely to that of cast-iron tubbing.

The pressure on the inner surface is zero. That is, p equals 0 when r equals r_1, and hence by equation (4)

$$0=a+\frac{b}{r_1^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

Let the pressure on the outer surface be p_0. Then p equals p_0, when r equals r_0, and by equation (4)

$$p_0=a+\frac{b}{r_0^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

The simultaneous simple equations (6) and (7) being solved for a and b, it follows that:

$$a=\frac{p_0 r_0^2}{r_0^2-r_1^2}; \text{ and } b=-\frac{p_0 r_0^2 r_1^2}{r_0^2-r_1^2}.$$

These values can be inserted in equation (4), which could then be applied easily to find the intensity of the pressure p at any radius r, provided that the numerical values of p_0, r_1 and r_0 were given. It is more to the author's purpose to insert these values of a and b in equation (5). Then:

$$q=\frac{p_0 r_0^2}{r_0^2-r_1^2}\left(1+\frac{r_1^2}{r^2}\right)$$

For any value of r, the hoop stress q is thus determined.

Since this stress is greatest at the inner surface, that is when r equals r_1, let q_1 be its greatest value, and the equation becomes

$$q_1=\frac{2p_0 r_0^2}{r_0^2-r_1^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This will be referred to as the thick-cylinder formula for external pressure only. By simple algebraical transformations, it may be written

$$\frac{r_0}{r_1}=\sqrt{\frac{q_1}{q_1-2p_0}}\text{; or} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$t=r_1\left(\sqrt{\frac{q_1}{q_1-2p_0}}-1\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

where t is the thickness of metal.

Or, again, if it be desired to connect t with r_0

$$t=r_0\left(1-\sqrt{1-\frac{2p_0}{q_1}}\right) \quad . \quad . \quad . \quad . \quad . \quad (10a)$$

This is the form often quoted as being due to Prof. W. Aldis.

11.—Approximate formulæ for rapid calculation may be obtained as follows:

If in equation (8), r_0-t be written for r_1, then

$$q_1=\frac{p_0r_0}{t-\frac{t^2}{2r_0}}\text{; and } t=\frac{p_0r_0}{q_1-\frac{q_1t}{2r_0}}.$$

$\frac{q_1t}{2r_0}$ can be looked upon as a small correction applied to the denominator of this expression; but since t equals p_0r_0/q_1, approximately, $p_0/2$ can be written for $q_1t/2r_0$ and then:

$$t=\frac{p_0r_0}{q_1-\frac{p_0}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

If the correction $\frac{p_0}{2}$ be neglected altogether, the formula reduces to that found otherwise in section 8, namely:

$$t=\frac{p_0r_0}{q} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

The closeness with which these formulæ agree may be seen by taking, say, p_0 equal to 120 pounds per square inch, and r_0 equal to 90 inches.

The accurate formula (10a) gives, taking q as 15,000,

$$t=90\left(1-\sqrt{\frac{15000-240}{15000}}\right)=0{\cdot}724 \text{ inch.}$$

The least accurate formula (12) gives

$$t=\frac{120\times 90}{15000}=0{\cdot}720 \text{ inch.}$$

Or again, if p = 640 pounds per square inch and r_0 = 120 inches, formula (10a) gives t equals 5·280 inches; formula (11), t equals 5·230 inches; and formula (12), t equals 5·120 inches.

Equation (11) may be recommended as simple and giving results, under all circumstances, very closely agreeing with equation (10a).

The formulæ of Messrs. G. C. Greenwell, Bodart, Charles Combes, and Chaudron are based on equation (12); that of Prof. W. Galloway is of the form (11). A constant is added to some of these formulæ to allow for imperfection in casting and for

corrosion. Mr. T. A. O'Donahue's formula is based on equation (12); but it has taken a different shape, owing to the desire to make it include a casting allowance that should decrease as the pressure increases. The rule given by Prof. J. H. Merivale is (10a) with the inclusion of a factor of safety of 10; that due to Mr. G. H. Hollingworth is a modification of Mr. G. C. Greenwell's.

12.—In the more general case, there is an internal pressure p_1, in addition to the external pressure p_0.

Then, since p equals p_1 when r equals r_1:

$$p_1 = a + \frac{b}{r_1^2}$$

and since p equals p_0 when r equals r_0:

$$p_0 = a + \frac{b}{r_0^2}.$$

These give:

$$a = \frac{p_0 r_0^2 - p_1 r_1^2}{r_0^2 - r_1^2}; \text{ and } b = r_0^2 r_1^2 \frac{p_1 - p_0}{r_0^2 - r_1^2};$$

and equation (5) becomes

$$q = \frac{r^2 (p_0 r_0^2 - p_1 r_1^2) - r_0^2 r_1^2 (p_1 - p_0)}{r^2 (r_0^2 - r_1^2)};$$

hence

$$q_1 = \frac{2p_0 r_0^2 - p_1 (r_0^2 + r_1^2)}{r_0^2 - r_1^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

If this expression is negative, it means that the stress is tensile. Let f_1 be the greatest circumferential tensile stress; then f_1 equals $-q_1$, that is:

$$f_1 = \frac{p_1 (r_0^2 + r_1^2) - 2p_0 r_0^2}{r_0^2 - r_1^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

If, in equations (13) or (14), it is assumed that p_1 equals 0, the result of the preceding paragraph is obtained. If it be assumed that p_0 equals 0, the usual formula for thick cylinders subjected to internal pressure only, is obtained.

13.—*Other Theories of the Thick Cylinder.*—Other methods of estimating the greatest stress in a thick cylinder have been used. The theoretical basis of some of these is here briefly set forth, and the chief objections to them are indicated. The formulæ are generally given for cylinders under internal pressure only, but attempts have been made to adapt them to external-pressure problems. It is the more necessary to describe these theories, as the modified formulæ given elsewhere are often erroneous.

Taking first the theory which supposes that the thickness of

the cylinder remains constant when the pressure is applied, the cylinder must be imagined to be built up of a number of concentric elemental rings of thickness δr and of unit-length parallel to the axis. When the external and internal pressures are applied, the circumferential increase of length of all the elemental layers will be the same. If this increase be λ, then the strain in a ring of radius r will be $\frac{\lambda}{2\pi r}$; the stress, with the same notation as before, is q, and by the definition of Young's modulus of elasticity (E), it follows that

$$q=\frac{E\lambda}{2\pi r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

The circumferential force in each ring is $q\delta r$ and the total resistance to compression, in unit-length, becomes $2\int_{r_1}^{r_0} q dr$. Consequently

$$2(p_0 r_0 - p_1 r_1)=2\int_{r_1}^{r_0} q dr$$

whence, substituting for q from equation (15) and integrating:

$$p_0 r_0 - p_1 r_1 = \frac{E\lambda}{2\pi} \log_e \frac{r_0}{r_1}.$$

For external pressure only, writing q_1 for the greatest stress, this gives:

$$\log_e \frac{r_0}{r_1} = \frac{p_0 r_0}{q_1 r_1}; \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16)$$

and the stress at any other radius may be most easily found from the relation:

$$qr = \text{constant}.$$

Equation (16) has no advantage in simplicity of practical application, and it is based on an assumption which is known to be untrue. Moreover, equation (15) is not a correct statement. The strain $\frac{\lambda}{2\pi r}$ is due to the normal compressive force, as well as to the circumferential stress; and it is only this latter part that can be divided into the stress q to obtain the modulus E.

14.—In the previous paragraph, it was assumed that the thickness of the cylinder remained constant. Another assumption is that the sectional area does not alter. The foundation of a theory on this basis was due to Prof. Barlow.

Suppose that, after the pressure is applied, the radii r_1 and r_0 become $r_1 + n_1 r_1$ and $r_0 + n_0 r_0$. It will readily be seen that n_1 and

n_0 are the circumferential strains of the inner and outer surfaces. Since the sectional area does not alter:

$$\pi(r_0^2-r_1^2)=\pi[(r_0+n_0r_0)^2-(r_1+n_1r_1)^2];$$

and, neglecting n^2 as a very small quantity, this reduces to:

$$\frac{r_1^2}{r_0^2}=\frac{n_0}{n_1}.$$

Putting the stress proportional to the strains, then:

$$\frac{n_0}{n_1}=\frac{q_0}{q_1}; \qquad (17)$$

$$\text{and } \frac{r_1^2}{r_0^2}=\frac{q_0}{q_1}. \qquad (18)$$

This relation may be written

$$qr^2=\text{constant} \qquad (19)$$

The total force in a ring of unit-length parallel to the axis is, as before:

$$2\int_{r_1}^{r_0}q\,dr=2q_1r_1^2\int_{r_1}^{r_0}\frac{1}{r^2}dr=2q_1r_1^2\left(\frac{1}{r_1}-\frac{1}{r_0}\right)=2q_1r_1\left(1-\frac{r_1}{r_0}\right).$$

Equating this to the external force:

$$p_0r_0=q_1r_1\left(1-\frac{r_1}{r_0}\right), \qquad (20)$$

from which the thickness may be found.

In terms of q_0, equation (20) takes the simple form:

$$p_0r_1=q_0t;$$

and the stress at any other radius may be found from equation (19).

If the radii be known, the greatest stress produced by a given pressure is:

$$q_1=\frac{p_0r_0^2}{r_1t}.$$

If, in this equation, r_1 were the mean radius, it would agree with the more accurate theory of equation (8). The assumption that the sectional area does not change is, however, unjustifiable; and the statement involved in equation (17), that the circumferential strains depend on the corresponding circumferential stresses only, is also erroneous.

III.—Resistance to Collapse.

15.—In the investigation of the stresses in a thick cylinder under an external normal pressure p_0 two systems of stress (p and q) at right angles were found. The first system tends to increase the length of the circumference of any elementary thin cylinder into which it is imagined that the whole is divided. At the same

time, it increases the length, parallel to the axis, of any portion of such a cylinder: these effects are both very small. A third, which is larger, but still small, is the tendency to reduce the thickness of the metal. The action of the other system, the hoop-stresses q, is to increase the thickness and length parallel to the axis and to reduce the circumference.

The nett result is a slight increase in the length, accompanied by a diminution in the diameter. The cylinder remains circular, but it is of diminished radius. When the external pressure is increased, however, above a certain critical value, it becomes possible for the cylinder to bend slightly and to take up a position of which the cross-section is other than circular. To guard against failure by collapse it is necessary to limit p_0 to some value less than this critical value.

16.—The determination of the critical value is a matter of some difficulty, but considerable help may be obtained from a paper by Prof. G. H. Bryan.*

Imagine a thin cylinder of great length to suffer a deformation in two dimensions; and let the deformation consist of inextensional bending. That is, it must be such that if any line whatever be drawn on the middle surface of the cylinder, this line will remain unaltered in length after the deformation has occurred. The circular section, for example, might become elliptical; or the cylinder might have one or more corrugations running throughout its entire length.

This inextensional deformation is satisfactory for this purpose, as it seems probable that any change in the shape of the cylinder which required a stretching or compression of the material (in addition to the pure bending) would require a greater value of p_0 than that which would suffice for bending without stretch. Prof. Bryan's result is that such a deformation is possible, if:

$$p_0 = \frac{2}{3} \cdot \frac{\mathrm{ER}^3}{1-\sigma^2}(n^2-1);$$

in which E and σ denote Young's modulus and Poisson's ratio for the material; R is the thickness divided by the mean diameter; n is any integer greater than 1; for the least value of p_0, when n equals 2:

$$p_0 = \frac{2\mathrm{ER}^3}{1-\sigma^2} \quad \ldots \ldots \ldots \quad (21)$$

* *Cambridge Philosophical Society Proceedings*, 1888, vol. vi., page 287.

This is an expression for the external pressure at which there can be some form of the cylinder other than circular; in other words, this is supposed to be the critical pressure at which the cylinder becomes unstable.

17.—The cylinder referred to is a plane circular one of infinite length. It is free from flanges or stiffening rings, and the effect of these has still to be considered.

Since the material dealt with is invariably cast-iron, and since the values of E and σ are rarely determined experimentally, it will be well to simplify the formula by assuming average values. Thus, taking, in pounds and inch-units, E equals 18×10^6 and σ equals $\frac{1}{4}$:

$$p_0 = 4 \times 10^7 R^3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (22)$$

In words, the equation (22) states that a cast-iron cylinder of infinite length will not collapse unless the external pressure (in pounds per square inch) exceeds 40 million times the cube of the ratio of the thickness to the mean diameter.

As a numerical example, it will be recognized that a cylinder 1 inch thick and 100 inches in diameter would require a pressure of 40 pounds per square inch to cause collapse. This allows for no factor of safety; and the lack of homogeneity of the material, combined with the inexact circularity of the original cylinder and the somewhat uncertain nature of the theory (unconfirmed as yet by experiments on a large scale), would render a high factor of safety desirable. The theory, however, receives considerable support from the experiments so far made on pipes. Messrs. A. P. Carman and M. L. Carr* have used tubes up to 10 feet in length. They found that the portion of the length affected by collapse was generally not greater than 12 times the diameter. For values of R, such as the writer has dealt with, they found, instead of the 4 given for cast-iron in equation (22), the numbers $2\frac{1}{2}$ for brass and 5 for cold-drawn seamless steel.

18.—The cylinders used in the practical problem differ from those considered in the previous paragraphs in having horizontal flanges and stiffening rings at fixed intervals in their length. The effect of these is to reduce the effective length of the cylinder to an amount which is generally very much less than the diameter.

* "Resistance of Tubes to Collapse," by Messrs. A. P. Carman and M. L. Carr, *University of Illinois, Bulletin*, 1906, vol. iii., No. 5, pages 1-26; and paper by Mr. A. P. Carman, *Physical Review*, 1905, vol. xxi., pages 381-387.

The portion of the tubbing between one flange or ring and the next is effectively a thin cylinder with fixed ends, and a consequence of the ends being fixed is that the middle surface of the cylinder cannot take up the inextensional deformation discussed earlier. Its cylindrical shape cannot be changed without appreciable stretching of some portions of the material. The stretching would no doubt be confined to definite local regions, and the greater part of the surface would bend without extension. It is clear, too, that the less the effective length of the cylindrical shell the greater is the proportion of stretching to bending; and hence, also, the greater is the critical pressure required to make the deformation possible.

It has been shown by Prof. A. E. H. Love that for a cylinder of mean diameter, d, and thickness, t, the effective length (that is the distance between the horizontal rings) should be proportional to the geometric mean between the thickness and the diameter. This may be stated by the formula:

$$l = k\sqrt{td};$$

in which l is the vertical distance between the rings, and k is some constant to be determined by experiment.

19.—Experiments which have been made on cylinders, of which the effective length is sufficiently short to influence the results, provide various empirical formulæ. They all approximate, more or less closely, to the form

$$l = k\frac{t^2}{pd} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

But they seldom, if ever, refer to cylinders of cast-iron.

If such a form as equation (23) be accepted, the theory of dimensions shows that the constant, k, is proportional to the first power of the coefficient of elasticity or of the strength of the material. As the problem is fundamentally one of elasticity, the equation may be written:

$$l = c\,\frac{\mathrm{E}t^2}{pd};$$

and it remains to find a suitable value of the constant, c.

Sir W. Fairbairn's experiments * give, with sufficient accuracy if the thickness is not less than $\frac{3}{8}$ inch:

* "On the Resistance of Tubes to Collapse," by Mr. William Fairbairn, *Philosophical Transactions of the Royal Society of London*, 1858, vol. cxlviii., page 389; "On the Resistance of Boiler Flues to Collapse," by Prof. William Cawthorne Unwin, *Minutes of Proceedings of the Institution of Civil Engineers*, 1876, vol. xlvi., page 225; and *The Elements of Machine Design*, by Prof. William Cawthorne Unwin, eleventh edition, 1890, part i., page 82.

$$l=9{,}672{,}000\frac{t^2}{pd}.$$

If E for wrought-iron be taken as 30×10^6, this gives:

$$c=0\cdot 32\ \ldots$$

Whence, for cast-iron, equation (23) becomes something like:

$$l=5\times 10^6\frac{t^2}{pd}.$$

In boiler-flues, a factor of safety of 9 or 10 is allowed. For cast-iron tubbing, in the absence of further data, the factor would have to be considerably larger. The following rule might be expected to be safe:

$$l=200{,}000\frac{t^2}{pd}. \qquad (24)$$

20.—A question which does not appear to have received sufficient attention is that of the stability of the stiffening rings. These rings must be sufficiently strong to prevent any change in the position or direction of the part of the cylindrical shell to which they are attached. Assuming this condition satisfied, it is still necessary to ensure that the rings will not collapse. The writer has already considered the collapsing of the shell on the assumption that the rings are sufficiently strong. The stability of the rings is quite a different question, and is a most important one.

The stability of circular rings under normal pressure has been considered by Prof. M. Lévy.* The result of his theory may be stated as follows: If x be the pressure per unit-length of the circumference of the ring, and r be the mean radius, then collapse may take place when:

$$x=\frac{3EI}{r^3}: \qquad (25)$$

I being the moment of inertia of the section of the ring, about a line through its centre of gravity parallel to the axis.

To apply this, a complete ring of tubbing (assuming the vertical joints capable of transmitting stress) might be taken, and its moment of inertia to satisfy the above formula might be calculated.

A more severe test is to take that portion only of the tubbing ring which may be considered to form part of the effective area

* *Journal de Mathématique*, Liouville, 1884, series 3, vol. x., page . See also Love's *Elasticity*, 1906 edition, page 405.

of the middle horizontal stiffening rib. In fig. 5 (plate ii), for example, AB and CD are bisected to obtain the length l. It is practically the distance apart of the rings or flanges, measured from centre to centre. Formula (25) must then be applied to a ring having the section shaded in fig. 5. If the thickness of the shell and the dimensions of the stiffening rings be settled on other considerations, the formula might be used to determine the distance apart of the rings. It may be written:

$$l=\frac{3EI}{pr^3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

It is frequently suggested that the cylinder should not be assumed to gain in strength to resist the circumferential stresses by the addition of the rings; and, on the other hand, that the rings should not be supposed to receive any assistance from the shell. Such suggestions cannot, however, be accepted. It is perfectly clear that, in any given design, if the thickness of the shell be increased, the sectional area of the stiffening rings may be decreased, or they may be spaced at greater intervals.

21.—Let it be assumed that the thickness of the ribs is equal to that of the shell. Then, if w is the width of the stiffening ring as shown in fig. 5, the formula (26) may be said to involve the three unknown quantities w, l and t. In any given case, the writer will suppose that the pressure and the radius of the shaft are known, and to simplify numerical calculation he will take the modulus, E, equal to 18×10^6 pounds per square inch.

Of the three unknown quantities, two may be chosen arbitrarily, or some proportionality may be assumed to exist between the three. In the former case, convenient practical numerical values may be given to, say, w and l and the t may be calculated. In the latter, two such relationships may be chosen as:

$$l=at, \text{ and } w=bt: \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (27)$$

where a and b are any numbers thought suitable.

The position of the centre of gravity of the portion under consideration (fig. 6) is given by:

$$z=\frac{lt+w^2+2wt}{2(l+w)};$$

and the required moment of inertia is:

$$I=\frac{lt^3}{12}+lt\left(z-\frac{t}{2}\right)^2+\frac{tw^3}{12}+tw\left(\frac{w}{2}+t-z\right)^2.$$

Equation (27) will reduce this to the form:

$$I=ct^4;$$

in which c has a definite value, depending on the choice of a and b. Equation (26) can then be written:

$$at=\frac{3Ect^4}{pr^3} \text{ or } t=kr\sqrt[3]{p} \quad . \quad . \quad . \quad . \quad . \quad . \quad (28)$$

where k stands for $\sqrt[3]{\frac{a}{3Ec}}$.

If the factor of safety be F, the pressure must be multiplied by F before insertion in equation (28); or the equation may be written:

$$t=kr\sqrt[3]{pF} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (29)$$

The following table gives values of k for different proportions of w and l likely to occur in practice. It is based on E equals 18×10^6.

TABLE I.—VALUES OF k IN THE FORMULA $t=kr\sqrt[3]{pF}$.

	$l=3t$.	$l=4t$.	$l=5t$.	$l=6t$.	$l=8t$.	$l=10t$.
$w=2t$ ...	0·00249	0·00265	0·00278	0·00290	0·00311	0·00328
$w=3t$ ...	0·00187	0·00199	0·00210	0·00218	0·00234	0·00247
$w=4t$ ...	0·00151	0·00160	0·00168	0·00175	0·00187	0·00198
$w=5t$ ...	0·00126	0·00134	0·00141	0·00146	0·00156	0·00165

IV.—OTHER FORMULÆ AND METHODS OF FAILURE.

22.—*Plate-Formula.*—Supposing that, in any example of tubbing, the ribs and flanges are sufficiently strong to perform any duties which may be required of them. There may be then complete confidence in the plate, if it has the thickness given by the formula for the strength of flat rectangular plates.

In this formula, if a, b and t are respectively the length, breadth and thickness of the plate, a being greater than b, and all being in inches; and if p be the pressure on its surface in pounds per square inch; then the greatest stress, in pounds per square inch, is given by:

$$f=\frac{1}{2}\cdot\frac{pa^4b^2}{t^2(a^4+b^4)} * \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (30)$$

If the stress be taken as 20,000 pounds per square inch, equation (30) may be used to find the necessary thickness of the plate. It takes the form:

$$t=0{\cdot}005\, a^2b\sqrt{\frac{pF}{a^4+b^4}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (30a)$$

* *The Elements of Machine Design*, by Prof. William Cawthorne Unwin, eleventh edition, 1890, part i., page 93; *Applied Mechanics*, by Prof. John Perry, 1897, page 326; etc.

Fig. 7 (plate ii.) shows the portion of plate to which this formula may be applied. The facts—that the external pressures, under normal conditions, converge towards the centre of the cylinder, and that the plate has a camber convex towards the load—are not taken into account in the formula (30). The result is that the plate is much stronger than the formula supposes it to be, and hence a small factor of safety may be allowed. A factor of three or four should be ample, but it must be allowed on the ultimate *tensile* strength of the material.

23.—*Hoop Stress.*—When a portion of the plate including one stiffening ring (as in section 21 and fig. 6) is considered, an estimate of the magnitude of the circumferential stress may be obtained by constructing a formula of the type ordinarily used for thin cylinders.

Thus, the resolved portion of the pressure is $2prl$ and the resistance offered by the material is $2qt\ (l+w)$. Equating these, then:

$$qt\,(l+w)=prl\,; \qquad (31)$$

and choosing l and w in terms of t, this expression may be reduced to:

$$t=K\frac{pr}{f} \qquad (32)$$

24.—*Stress due to Weight.*—In exceptional cases, or when the depth of the tubbing is very great and supporting curbs are not employed at intermediate points in the depth, the stress due to the weight of the tubbing itself may become appreciable. In such cases the weight should be carefully calculated. In general, however, this will be unnecessary. The stress due to weight would probably never exceed, say, ¼ ton per square inch for each hundred feet of depth. If this estimate be correct, a length of 1,000 feet of unsupported tubbing would produce a stress probably well within 2½ tons.

When the weight is supported by curbs, situated at intervals in the depth, the stress due to this cause may be neglected.

25.—*Corrosion.*—The question of how much of the metal is eaten away or rendered valueless by corrosion is a most difficult one. Attention has recently been called to it by Mr. H. W. G. Halbaum, who very properly insists on the need for more data.

It is a question which depends so much upon local circumstances that it must be left to the designer to settle in each

individual case. When the complete dimensions of the tubbing have been settled on strength-considerations, an allowance for corrosion should be distributed all round. It appears to be distinctly advisable to remove this allowance from the contingencies covered by the factor of safety. Its amount must depend on the chemical and electrolytic capabilities of the soils and water of the district; on the length of time for which the structure is required to last; on the nature and amount of the protective covering, if any, with which the metal is coated; and, very probably, on the structure and composition of the iron itself.

The writer thinks that it is safe to say that, when the metal is unprotected, this allowance should not be less than ¼ inch. Probably few engineers would care to allow more than 1 inch.

V.—Practical Examples and Conclusion.

26.—As an example of the use of these formulæ, the writer will take a shaft 600 feet deep and 14 feet in internal diameter.

If the greatest pressure is that due to a head of 600 feet of water, it follows that:

$$p=\frac{62 \cdot 4 \times 600}{144}=0 \cdot 433 \times 600=260 \text{ pounds per square inch.}$$

Let the ultimate strength of the material be taken as at least 100,000 pounds per square inch in compression, and 20,000 pounds per square inch in tension.

Suppose that there are eight segments in each ring and that the height of each is 2 feet 6 inches; and that there are three vertical and three horizontal rings on each segment, in addition to the flanges. Each segment is then divided by the ribs into sixteen plates, about 15 inches long by 6 inches deep.

The plate-formula gives:

$$t=\sqrt{\frac{1}{2}\frac{pa^4b^2}{f(a^4+b^4)}}=\sqrt{\frac{260 \times 15^4 \times 6^2}{2 \times 5{,}000(15^4+6^4)}}=0 \cdot 953 \text{ inch.}$$

This allows a factor of safety of 4, and an allowance must be made for corrosion and defects in casting.

As an alternative design, let it be supposed that there is only one horizontal and one vertical rib between the flanges. The values of a and b are then each doubled; that is, the thickness must be twice as great, or:

$$t=1 \cdot 906 \text{ inches.}$$

A design intermediate between the two might have three vertical and two horizontal ribs. The rectangles are then about 15 inches by 8 inches, and

$$t=\sqrt{\frac{260\times 15^4\times 8^2}{2\times 5{,}000\,(15^4+8^4)}}=1{\cdot}240 \text{ inches.}$$

27.—In the previous section, the thickness of the tubbing has been calculated without reference to the dimensions of the stiffening rings. To take these into account, equation (29) must be used. If w equals $3t$, l equals $4t$, and a factor of safety of 4 be adopted, it is found (from Table I.) that k equals 0·00199, and equation (29) becomes:

$$t=0{\cdot}00199\times 84\times\sqrt[3]{260\times 4}=1{\cdot}690 \text{ inches.}$$

Then w equals $3t$ equals 5·070 inches, and l equals $4t$ equals 6·770 inches.

This would be a suitable design. It should be noticed that it requires a greater thickness than that given by the plate-formula in section 26.

To see the effect of changing the ratio of w or l to t, the same data as before may be taken, but l may be made equal to $3t$. Then, k equals 0·00187, and hence t equals 1·590 inches, w equals 4·780 inches, and l equals 4·780 inches. More stiffening rings are required, but the thickness of the plate and the width of the rib are reduced.

28.—The example contained in the two preceding sections is one in which the final dimensions are determined by the ring-formula. The plate-formula need not have been used if it had been known beforehand that it would give a less thickness than that required by the ring-formula. The writer will now find the dimensions of tubbing for the same shaft, when each segment is provided with one horizontal and one vertical rib only. Suppose the segments to be about 5 feet wide by 3 feet deep. Using the ring-formula, w may be made equal to $4t$; and, since the ribs are far apart, l equals $10t$. Then:

$$t=0{\cdot}00198\times 84\times\sqrt[3]{4\times 260}=1{\cdot}685 \text{ inches;}$$

and w equals 6·740 inches, and l equals 16·850 inches. Now test this result by the plate formula. If the plates are 28 by 16 inches, a must be equal to 28 (the greater), and b equal to 16 inches. Then:

$$t=2{\cdot}465 \text{ inches,}$$

which is larger than before. The actual thickness must now not be less than this.

Trying the ring-formula again, take w equals $2t$ and l equals $6t$, as this will give about the right value of l. Then:

$$t=0{\cdot}00296\times 84\times \sqrt[3]{4\times 260}=2{\cdot}740 \text{ inches};$$

w equals 5·480 inches, and l equals 16·440 inches, and it can be seen that these dimensions are satisfactory.

29.—It will be interesting now to estimate the average circumferential stress in the material in this last example.

From equation (31):

$$q=\frac{prl}{t(l+w)}=\frac{260\times 84\times 16{\cdot}44}{2{\cdot}74\,(16{\cdot}44+5{\cdot}48)}=6{,}000 \text{ pounds per square inch,}$$

approximately.

This result is within the limits of safety.

30.—Before concluding this paper, it will be well to summarize the results, in so far as they affect the method to be adopted in most rapidly determining the dimensions of cast-iron tubbing for any given external pressure and diameter of shaft: (*a*) If the stiffening rings are to be closely spaced, use the ring-formula (29) first, and then test the result by the plate-formula (30). (*b*) If the rings are far apart, use the plate-formula (30*a*) first, and then find the size of the stiffeners by the ring-formula.

As the factors of safety used in the examples may not commend themselves to all engineers; and as, in exceptional cases or in the light of further experience, it might be desirable to modify these factors, the equations (29) and (30) have been purposely left in such a form that the designer may insert whatever factors he pleases.

It will be clear that, as given, the expressions refer to strength only, and that if an allowance is to be made for corrosion it can be applied to the results calculated as above. Such an allowance should be added to t; w and l being left unchanged.

31.—*Magnitude of the Pressure.*—The pressure which the tubbing has to withstand is usually calculated as that due to a column of water of a height equal to the depth of the tubbing. When, however, there are water-bearing strata between beds of impervious rock, it may be necessary to measure the depth of the shaft from the outcrop of the water-bearing strata.

It is perhaps possible, with certain soils, to encounter pressures greater than that due to an equal head of water. In such cases Prof. Rankine's formula may be used. Thus, if h be the depth in feet, w the weight of a cubic foot of the earth, and ϕ the

angle of repose, or friction-angle, of the earth, the pressure in pounds per square foot on the surface of the tubbing at the base is:

$$p = wh \tan^2\left(45^\circ - \frac{\phi}{2}\right),$$

or, as it may be written,

$$p = wh\frac{1 - \sin\phi}{1 + \sin\phi}.$$

Experience with retaining walls appears to show that Prof. Rankine's theory considerably overestimates the magnitude of the pressure.

As a rough rule, it may be taken that the pressure in pounds per square inch rarely, if ever, exceeds one-half of the depth of the shaft in feet.

The PRESIDENT (Mr. J. H. Merivale), in proposing a vote of thanks to Dr. Morrow, said that the formulæ with which they had been familiar hitherto did not take the flanges into account.

The vote of thanks was cordially adopted.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN DOWELL'S ROOMS, EDINBURGH, OCTOBER 12TH, 1907.

DR. ROBERT THOMAS MOORE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, who had been duly nominated, were elected:—

MEMBERS—

Mr. WALTER BURT, Baraboni Colliery, Asansol P.O., Bengal, India.
Mr. THOMAS CLARK, Camerton Colliery, Workington.
Mr. ROBERT CRICHTON, Castlepark, Linlithgow.
Mr. ROBERT GILLESPIE, Hillhead, Coylton, Ayr.
Mr. THOMAS GRAY, Wemyss Coal Company, Limited, East Wemyss.
Mr. JOHN S. KEAN, 3, Church Street, Ayr.
Mr. THOMAS McCULLOCH, Auchinleck.

DISCUSSION OF MR. JOHN F. K. BROWN'S PAPER ON "A STRETCHER FOR USE IN MINES."*

Mr. JAMES BARROWMAN (Hamilton) asked whether there was not need for greater rigidity in the stretcher, especially in instances of broken limbs or back strain. The stretcher, as exhibited, seemed too slack.

Mr. T. TRAIN CHRISTIE (Edinburgh) said that it might be advantageous if this stretcher were taken up by ambulance classes and tested by them. He thought that there was a great deal in what Mr. Barrowman said as to the advisability for more rigidity in the stretcher, especially for use in accidents which had resulted in broken limbs. The idea was to get the patient in as rigid a position as possible, consistent, of course, with comfort.

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 162; and vol. xxxiv., page 70.

Mr. THOMAS THOMSON (Hamilton) said that he was rather afraid that this stretcher would not suit some collieries. It was impracticable to have the stretcher suspended between two tubs as suggested by Mr. Christie, because if anything went wrong, in steep workings, with the first tub, before the second one could be stopped, it would very likely run on to the patient. Even on a level road, the first tub would require to be pushed by one person and the second by another person; and if anything went wrong with the first person, the second tub would be likely to run on to the patient. In the case of an accident happening at night, it was very difficult to get the patient removed to the pit-bottom, as generally the roads were blocked with loaded tubs, which could not be shifted unless the pit was working; and, in many cases, a patient had to be carried over the top of these tubs. He quite recognized the point as to the necessity of rigidity of the stretcher, particularly where an accident had resulted in a broken limb.

Mr. J. F. K. BROWN, replying to the discussion, said that he intended the appliance to be used principally on a bogie, but it could also be used on a hutch. The weight of the injured man himself would give a certain amount of rigidity to the stretcher. As he had already mentioned, the stretcher might nip the back if any ribs were broken. It could be used as an ordinary stretcher by using the hooks provided for carrying the stretcher by means of poles, and it would be recognized that the arrangement could be easily carried about.

The discussion was closed, and a vote of thanks passed to the author.

DISCUSSION OF MR. JAMES BAIN'S PAPER ON "RESCUE-APPARATUS FOR USE IN MINES."*

Mr. W. D. LLOYD (Normanton) said that the Weg apparatus was, in general principles, the same as that described by Mr. W. E. Garforth, in June, 1906,† but the various parts had been altered and improved considerably since that time. The oxygen was carried in two steel cylinders, curved to fit the body, and supported above the hips by leather straps attached to a jacket or waistcoat, made of moleskin or other strong material. This

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 72.

† *Ibid.*, 1906, vol. xxxi., page 625.

garment, in addition to serving as a covering for the body, also formed a foundation for the apparatus, with the object of distributing the weight over the shoulders and other parts of the body. The lung-governing valve for regulating the supply of oxygen was the same in principle as the valve previously described, but it was made in a more compact and portable form, with an independent bye-pass valve (as an extra precaution should the principal valve get out of order). The two cylinders were coupled together by a small copper pipe passing round the back, and were opened and shut by special cocks which could be operated at will: the usual practice being to utilize the contents of the right-hand cylinder during the exploration, and afterwards to use the left-hand cylinder while returning to the shaft or place of safety. A pressure-gauge was provided, and could be read by the wearer. The mouthpiece was held in place by the inhaling and exhaling pipes, which were carried over the head and fastened to an ordinary miner's leather cap. These pipes were strongly made in the form of a square twin-pipe, and, besides securing the mask, they acted as a protection to the head, somewhat like a fireman's helmet. They could be provided with a hinge, made of flexible metallic pipe, which allowed the helmet to be worn within certain limits of size by any person. It was, however, strongly recommended, both for safety and hygienic reasons, that each man should have his own mouthpiece. An elastic strap was also attached to each side of the mouthpiece and buckled to a leather flap at the back of the cap, thereby keeping the mouthpiece firmly in position.

The purifier containing the caustic alkali was carried in a rectangular metal case on the wearer's back, through which the vitiated air passed, by which method the purification was improved; and such an arrangement adapted itself to an easy and comfortable connection to the helmet. After leaving the regenerator, the purified air passed to a reservoir-bag made of indiarubber, carried inside the lower portion of the jacket, whence it returned to the inhaling pipe of the headpiece, through a pipe passing between the purifier and the jacket. The headpiece was coupled to the regenerator and inhaling pipe, by two specially flexible corrugated indiarubber pipes with suitable unions, such pipes being preferably protected by a light leather sheath.

A recent addition to the apparatus was a small fixed magnet

telephone, which it was proposed to attach to the headpiece of the leader of each rescue-party. The transmitter and receiver, which weighed less than one pound, could be worn without affecting the safety of the apparatus. During experimental trials, the wearer had spoken through 6,000 feet of cable.

Equipped with the Weg apparatus in this form, a trained man could undertake for 2 hours arduous work similar to that required during exploration work after an explosion; but, when engaged in less arduous work owing to the reducing valve being governed by the lungs, the oxygen supply would last a much longer period; and, whilst engaged in very light work, for instance watching a thermometer, the supply had been equal to 6 hours. At Altofts collieries, a team of 20 picked men, taken from various parts of the colliery, was being systematically trained in the experimental gallery filled with noxious fumes and made like the damaged roadways of a mine, with a view of being ready for any emergency at the particular colliery at which they were employed.

The weight of the apparatus varied according to the size of the cylinders containing the oxygen and the amount of caustic carried, that was, the length of time for which the apparatus was required, the one exhibited, designed for 2½ hours' work, weighed over 30 pounds. The apparatus was at present made almost entirely on the colliery premises at Altofts and in the hands of a skilled maker the weight would no doubt be materially reduced. The loaded cylinders weighed, for the heavy apparatus, 17 pounds, but at Altofts they expected to be able to reduce the dead weight. The apparatus had not, up to the present, been tried under water. The class of work carried on in the gallery was detailed in the report of the work done at Altofts colliery on March 23rd, 1907.*

Mr. James Barrowman (Hamilton) said that, after reading the various papers on this subject appearing in the *Transactions*, and after seeing the Weg apparatus as described by Mr. Lloyd, he was impressed with the great desirability of simplicity in apparatus of this kind. There was no doubt that ingenuity would still be exercised in making all the different types of apparatus simpler than they were at present. It was obvious that, if men

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 205.

were to be of any service in strange and dangerous places, they must go there with their minds pre-occupied as little as possible with the apparatus that they wore. If they had constant anxiety in regard to their own personal safety it was obvious that they would not be in a position to do a great deal on behalf of those whom they were endeavouring to rescue. If rescue stations were to be established, it must be with the view of being alive to all the improvements as these were made. In these circumstances, he should think that the apparatus at a station should not require to be of any final sort, and, as was suggested in Mr. Bain's paper, there should not be too many sets. Further, he held that the training, which men in connection with these stations would have to undergo, would require to be of a more thorough character than that given, say, at ambulance classes. He did not think that it would be sufficient to give a man a certificate of proficiency after he had passed through a certain course. He rather thought that those who were likely to use the apparatus would need to continue using them, so that they would become familiar with them and would be ready and proficient if called upon in any emergency. He could see from the descriptions that were given in the papers that the different types of apparatus were apt to get out of order through rusting or fouling with acid or otherwise. It was perfectly plain, if the apparatus was to be of any real service, that it must be placed in the hands of a person who would take an intelligent interest, not only in the station as a whole but in every detail of the appliances. A superior person must therefore be placed in charge of such apparatus. The necessity for keeping everything correct, even to the smallest detail, was perfectly obvious because the life of a man depended probably on everything being in order. He should think that even a kink taking place in the flexible indiarubber pipe on the Weg apparatus might stop the flow of necessary air, and that a man might be unconscious before he was aware himself that anything was wrong.

Mr. James Armour (Leven) stated that the Fife and Kinross Coalmasters' Association had just agreed to the establishment of a central rescue station at Cowdenbeath.

Mr. R. W. Dron (Glasgow) said that the point raised by Mr. Barrowman was of the greatest importance in discussing the

question of rescue-apparatus. This was not only a question of apparatus, but it was a matter of *personnel* as well. If a rescue station were to be formed, it would require to be accompanied by a trained body of men on the same lines and principles as a lifeboat-crew. Workmen could hardly be expected to give their services voluntarily, and they should be paid their shift's wage for the time spent in drilling at the rescue station. In each colliery there should be three or four men connected with the rescue squad, who would be expected to take regular drills, and to be always at hand when called upon. He thought that the success of a rescue station would depend as much on the personal element as on the efficiency of the apparatus.

Mr. George Murdoch said that about fifteen months ago he had an opportunity, along with a party of students from the Coatbridge Mining School, of witnessing a demonstration given by Mr. Lloyd at Normanton in the rescue station erected by Mr. Garforth. He thought that the demonstration proved the great utility of the Weg apparatus under circumstances such as were sometimes to be found in colliery districts. They had also an opportunity of seeing another apparatus in use at Birdwell rescue station near Barnsley. Mr. Walker's special apparatus was in use in this case. One of the students was equipped with it and set to build up a brick-wall, and he was engaged at this for fully 15 minutes. When relieved, he was much exhausted, and the experiment proved clearly to him (Mr. Murdoch) the necessity for having men specially trained for this work. and also the importance of the personal element in the success of the operations. If once the idea of panic got into the mind of a man, no matter how perfect the apparatus, he was not likely to do much with it. In his opinion, the establishment of a central rescue station would be very desirable, in a district where it could serve a large number of collieries in the event of accident.

The President (Dr. R. T. Moore) remarked that there was a good deal in what the previous speakers had said about the necessity of having trained men to use appliances of the kind under consideration. If untrained men penetrated into a dangerous atmosphere, and found a difficulty in breathing, they were apt to get into a panic, no matter how perfect the apparatus was; and that certainly seemed to point to the necessity of having at the central

station a body of trained and efficient men. In these days of telephones and motor-cars, one could very speedily convey the squad from the central station to any colliery in the neighbourhood, where their services might be required. It would be of great importance to have at least one man at each colliery who was able to use the apparatus. This apparatus would no doubt be useful in building stoppings round a fire where one could not get fresh air, or it might be useful in restoring ventilation after a fire or an explosion. As for rescuing men after an explosion, it was a little difficult to know where the advantage lay. If the atmosphere was so dangerous that the apparatus had to be used, then the workmen could not be expected to live in it. If there did happen to be a clear bit of air and the rescuers got at the men, how were they going to get them out? No doubt there was a great fascination in being able to go into dangerous atmospheres, but it seemed to him that it would only be on very few occasions that the apparatus would be useful.

The discussion was adjourned.

THE MINING INSTITUTE OF SCOTLAND.

SPECIAL MEETING,

HELD IN DOWELL'S ROOMS, EDINBURGH, OCTOBER 12TH, 1907.

DR. ROBERT THOMAS MOORE, PRESIDENT, IN THE CHAIR.

ADDITION TO THE RULES.

The following addition to the rules, after discussion, was adopted:—

A mining students' society connected with a university, technical college or mining class may be affiliated to the Mining Institute of Scotland on the application of its President, subject to the following terms and conditions:—

The members of an affiliated society shall have the right to attend the general meetings of the Institute, but not to take part in the discussions or vote on any question arising thereat, nor to attend the excursions of the Institute.

They shall have the same privileges as the members of the Institute in respect of access to the library of the Institute.

The Institute will supply to an affiliated students' society one copy of the current year's *Transactions* of the Institute, in parts as soon as published, for each member of the society for whom an annual subscription of 3s. has been paid, such member being eligible only while he is under tuition at a university, technical college or mining class.

The first subscription shall be due and payable at the date of acceptance of the society's application, and following subscriptions shall be due and payable at the annual meeting of the Institute in April of each year.

The Institute shall have the option of selecting two papers per annum from those read at the students' society, which papers shall become the property of the Institute, and shall be published in its *Transactions*.

The Institute will award prizes to the writers of these papers, if the council consider that the papers are of sufficient merit.

The Institute will present to each students' society paying the annual subscription for at least twenty members, one copy of the current year's *Transactions* of The Institution of Mining Engineers, and an additional copy for every forty members above the number of twenty.

These conditions are subject to the council of The Institution of Mining Engineers being willing to continue the separate issue of the *Transactions* of the Mining Institute of Scotland.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD IN THE PHILOSOPHICAL HALL, PARK ROW, LEEDS, JULY 23RD, 1907.

MR. J. R. R. WILSON, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

Messrs. J. Elce and E. Barraclough were appointed scrutineers of the balloting-lists for the election of Officers and Council, and also for representatives of the Institute on the Council of The Institution of Mining Engineers for 1907-1908.

The following gentlemen and a colliery firm, having been duly nominated, were elected:—

MEMBERS—

Mr. HERBERT NEWTON BERRY, Mining Engineer, 32, Hampton Road, Sheffield.

Mr. WILLIAM WOODYEAR BUCKTON, 72, Victoria Street, Westminster, London, S.W.

Mr. BERT FRANCIS BUXTON, Wilson Hill, Dore, near Sheffield.

Mr. JOSEPH OXLEY COOPER, Certificated Manager, Leeds Road, Glass Houghton, Castleford.

Mr. FRANK JEFFCOTT DYMOND, Mining Engineer, Liversedge Coal Company, Liversedge, Normanton.

Mr. PERCY N. HAMBLY, Mechanical Engineer, Grange House, Dropping Well, near Rotherham.

Mr. JAMES HARTLEY, Under-manager, Park-in-view, Church Fields, Castleford.

Mr. WILLIAM H. PATCHELL, Consulting Engineer, Caxton House, Westminster.

Mr. GÈZÀ REX, Professor at the Mining-engineering School, Selmecbànya, Hungary.

Mr. JOHN KENNETH LEWSON ROSS, Colliery Proprietor, Sydney, Cape Breton, Nova Scotia, Canada.

Mr. ALEXANDER JAMES MACKINTOSH SHAW, Engineer-in-charge, Pekin Syndicate Railway, Hsin Hsiang, Hsien, Honan, China.

Mr. ALFRED GORDON WADDIE, Engineer, 20, Roman Plaçe, Roundhay, Leeds.

ASSOCIATE—

Mr. GEORGE F. SCHOFIELD, Assistant Mechanical Engineer, Whitwood Collieries, Normanton.

STUDENTS—

Mr. DAVID GILCHRIST, University Student, 1, Gladstone Road, Scarborough.

Mr. ATHOLE FREDERICK HOLDEN, University Student, Nuttall Rectory, Nottingham.

Mr. JAMES S. WADSWORTH, Mining Pupil, Hill Crest, Harrogate.

SUBSCRIBING FIRM—

THE NEW MONCKTON COLLIERY COMPANY, LIMITED, Colliery Proprietors, Barnsley.

The Annual Report of the Council and the Treasurer's Statement of Accounts were presented, as follows:—

ANNUAL REPORT OF THE COUNCIL, 1906-1907.

The Council have pleasure in presenting to the Institute their Annual Report for the year 1906-1907.

The number of members who have paid their subscription for the year is 336; and the following is a comparison of the numbers for this year with the year 1905-1906:—

	1905-1906.	1906-1907.
Life members	1	1
Members (class *a*)	272	298
Associate members (class *b*)	11	12
Associates (class *d*)	7	5
Students (class *e*)	17	14
Subscribing firms	—	6
Totals	308	336

At the date of closing the accounts, subscriptions were due from 13 members.

Thirty-nine members were elected during the year, namely, 28 members, 3 associate members, 2 students and 6 subscribing firms. Three members have resigned since July 1st, 1906.

The Council regret to have to record the death of two members during the year, Mr. T. Andrews, F.R.S., and Mr. B. Behrens. The Council desire to place on record their high appreciation of the valuable researches carried out by Mr. Andrews in the department of metallurgy, and their sense of the great loss sustained by the Institute and the profession by his death.

The following table shows the balance of members for the year: —

Subscriptions paid to June 30th, 1906	308	
Subscriptions for the year 1905-1906, received since June 30th, 1906	7	
Members elected 1906-1907	39	
Members elected 1905-1906, who commenced payment from June 30th, 1906	7	
		361
Resignations from June 30th, 1906	8	
Deaths	4	
Subscriptions unpaid	13	
		25
Total number of subscribing members		336
Honorary members		7
Total		343

It is gratifying to record a nett increase of 28 in the number of members during the year, as compared with 6 in 1905-1906. The Council feel that it is a matter for congratulation that the appeal made in last year's report has been so readily responded to by the members of the Institute. It is evidence of that increasing vitality, which is so necessary if the Institute is to take its proper place in The Institution of Mining Engineers.

The balance at the bank for the year 1905-1906 was £49 0s 2d. The balance at the bank for the year just closed is £57 7s. 10d., and the cash in the Treasurer's nands £1 17s. 2d.

The Annual Dinner was held at Leeds on November 6th, 1906; and it was attended by 113 members and friends.

Six meetings have been held during the year, including a joint meeting with the Midland Counties Institution of Engineers. The Annual Meeting of 1905-1906 was held at Low Moor iron-works on the kind invitation of The Low Moor Company, Limited, when the iron-works were inspected and the members entertained at luncheon by the firm.

By the kindness of Mr. W. E. Garforth the members had an opportunity of inspecting the experimental gallery at Altofts colliery, and witnessing interesting and important trials of various rescue-appliances. A report of the trials is printed in the *Transactions*.

The following papers have been read at meetings held during the year:—

"The Pneumatogen: the Self-generating Rescue-apparatus, compared with Other Types." By Mr. R. Cremer.

"Elliott Washer and Hardy Dust-extractor and Grinder." By Mr. E. Greaves.

"Cost of an Electrical Unit at a Colliery." By Mr. P. C. Greaves.

"The Use and Care of Oxygen-breathing Apparatus." By Mr. M. H. Habershon.

"The Most Suitable Form of Guides for Cages for Winding from Deep Shafts: 1,500 Feet and Deeper." Prize Essay. By Mr. A. J. Kennedy.

"The Most Suitable Form of Guides for Cages for Winding from Deep Shafts: 1,500 Feet and Deeper." Prize Essay. By Mr. W. N. Routledge.

"The Importance of Scientific Mining in the Barnsley District." By Mr. R. Sutcliffe.

"Presidential Address." By Mr. J. R. R. Wilson.

The number of papers read is the same as last year. They dealt with subjects of considerable importance, and in all cases were productive of valuable discussions.

The Annual Meeting of The Institution of Mining Engineers will be held in Sheffield on September 4th, 5th and 6th, 1907, and the Council appeal to all members of the Institute to assist in making the meeting a success.

The Council note with satisfaction that the *Transactions* are issued more expeditiously, and would urge all members to support their efforts in this matter.

Owing to the termination of the Sheffield Literary and Philosophical Society's lease of the Assay-office Buildings, it removed to St. James Chambers, Church Street, Sheffield. Satisfactory arrangements were made for rooms in the Society's new quarters, where the library is now established and is open for the use of members.

At the request of the Committee appointed by the Home Office to report on the question of an Eight Hours' Day for Miners, your Council appointed representatives to give evidence. Mr. W. H. Chambers (Denaby) and Mr. J. Nevin (Mirfield) were selected, and gave evidence before the Committee.

The report and accounts were approved.

DR. THE TREASURER (MR. L. T. O'SHEA) IN ACCOUNT WITH THE MIDLAND

	£ s. d.	£ s. d.
July 1st, 1906.		
To balance at bank	46 7 5	
,, cash in Treasurer's hands	2 12 9	
		49 0 2
June 30th, 1907.		
To subscriptions for 1906-1907, 327 at £1 10s. ...	490 10 0	
,, 2 subscribing firms at £5	10 0 0	
,, 3 ,, ,, at £1 10s.	4 10 0	
		505 0 0
,, arrears, 1905-1906, 7 at £1 10s.		10 10 0
,, subscriptions paid in advance:		
5 at £1 10s.	7 10 0	
1 at £2 2s.	2 2 0	
		9 12 0
,, sale of dinner-tickets	28 0 0	
,, wine account	6 11 10	
		34 11 10
,, sale of *Transactions*		3 8 10
,, bank interest		3 5 0
,, Great Northern Railway Company, 1 year's dividend on £160 4 per cent. perpetual guaranteed stock, *less* income tax	6 1 8	
,, excess subscription	0 1 6	
,, National Association of Colliery Managers: share of expenses of Altofts meeting	0 8 0	
,, Mr. M. Hobson, 2 years' subscriptions to the North of England Institute of Mining and Mechanical Engineers	4 4 0	
		10 15 2
		£626 3 0

Examined and found correct,

JOSHUA WORTLEY & SONS,

CHARTERED ACCOUNTANTS.

Sheffield, July 17th, 1907.

INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS. CR.

	£ s. d.	£ s. d.
June 30th, 1907.		
By The Institution of Mining Engineers :—		
Call of 19s. on 343 members for 1906-1907 ...	325 17 0	
,, ,, 7 ,, 1905-1906 ...	6 13 0	
,, 20s. 2 ,, 1905-1906 ...	2 0 0	
	334 10 0	
Less, amount overpaid	0 1 0	
		334 9 0
,, excerpts and author's copies	11 1 10	
,, exchanges	5 5 3	
,, advance copies	8 13 3	
		25 0 4
,, binding *Transactions*	2 8 0	
,, printing and typing	31 6 0	
,, stationery	0 15 0	
,, Ordnance maps	0 3 0	
		34 12 0
,, rent of rooms	21 10 0	
,, insurance	0 3 0	
,, telephone	7 5 0	
,, hire of rooms	3 14 0	
,, cleaning rooms	2 16 0	
		35 8 0
,, Secretary's salary	50 0 0	
,, ,, expenses	6 8 8	
		56 8 8
,, telegrams and stamps		10 19 4
,, annual dinner		37 14 3
,, prize essays	6 6 0	
,, excess subscription	0 1 6	
,, removing library	4 2 2	
,, law costs	8 2 9	
,, Mr. M. Hobson's subscription	4 4 0	
,, indexing	2 10 0	
,, reporting	7 0 0	
		32 6 5
,, cash in bank	57 7 10	
,, cash in Treasurer's hands	1 17 2	
		59 5 0
		£626 3 0

Midland Institute of Mining, Civil and Mechanical Engineers: General Statement, June 30th, 1907.

Liabilities.

	£ s. d.	£ s. d.
Prize Essay Fund as at June 30th, 1906 ...	10 10 0	
Less, prizes awarded	6 6 0	
		4 4 0
Life members' subscriptions		25 10 0
Subscriptions paid in advance		9 12 0
Capital account as at June 30th, 1906 ...	633 11 0	
Add, increased value of *Transactions* ...	6 7 0	
	639 18 0	
Less, decreased value of Report on Safety-lamps	0 1 0	
	639 17 0	
Add, excess of income over the expenditure during the year, transferred from income account	15 5 7	
		655 2 7
		£694 8 7

Examined and found correct,

JOSHUA WORTLEY & SONS,
Chartered Accountants.

Sheffield, July 7th, 1907.

Assets.

	£ s. d.	£ s. d.
Cash in bank	57 7 10	
Cash in Treasurer's hands	1 17 2	
		59 5 0
Great Northern Railway Company, £160 4 per cent. perpetual guaranteed stock, at cost		196 2 10
Book-case as at June 30th, 1906	30 12 0	
Less, 10 per cent. depreciation, written off	3 1 3	
		27 10 9
7468 parts of *Transactions*		373 8 0
116 copies of Narratives of Outbursts of Gas, at 1s.		5 16 0
115 copies of Committee's Report on Safety-lamps, at 1s.		5 15 0
16 copies of Report of French Commission on use of Explosives, at 3s. ...		2 8 0
9 copies of Report of Prussian Commission on Falls of Roof and Stone, at 1s.		0 9 0
28 copies of North of England Report on Mechanical Coal-cutting, at 3s. ...		4 4 0
Outstanding subscriptions for 1906-1907, not yet received		19 10 0
		£694 8 7

ELECTION OF OFFICERS AND COUNCIL, 1907-1908.

The SCRUTINEERS reported the result of the ballot, as follows:—

PRESIDENT:

Mr. J. R. R. WILSON.

VICE-PRESIDENTS:

Mr. J. L. MARSHALL.	MR. G. R. THOMPSON.	Mr. W. WALKER.

COUNCILLORS:

Mr. J. E. CHAMBERS.	Mr. P. C. GREAVES.	Mr. H. RHODES.
Mr. H. ST. J. DURNFORD.	Mr. M. H. HABERSHON.	Mr. T. STUBBS.
Mr. J. J. ELEY.	Mr. F. W. HARDWICK.	Mr. E. W. THIRKELL.
Mr. T. GILL.	Mr. I. HODGES.	Mr. J. R. WILKINSON.

REPRESENTATIVES ON THE COUNCIL OF THE INSTITUTION OF MINING ENGINEERS, 1907-1908.

Mr. W. H. CHAMBERS.	Mr. T. W. H. MITCHELL.	Mr. W. WALKER.
Mr. W. E. GARFORTH.	Mr. J. NEVIN.	Mr. J. R. R. WILSON.
Mr. I. HODGES.	Mr. C. E. RHODES.	

ALTERATION OF RULES.

The PRESIDENT (Mr. J. R. R. Wilson) proposed, and Mr. W. E. GARFORTH seconded, the following alterations of rules, which were adopted:—

6.—For the words "at Barnsley," read "at Sheffield."

25.—For the word "twenty," read "thirty."

26.—Owners of collieries and employers of labour may subscribe annually to the funds of the Institute, and each such subscriber of £1 10s. annually shall be entitled to a ticket to admit two persons to the rooms, library, meetings, lectures and public proceedings of the Institute; and each such subscriber shall be entitled to have a copy of the *Proceedings* of the Institute sent to him.

Mr. W. ROUTLEDGE read the following paper on "Winding-ropes and Capels":—

WINDING-ROPES AND CAPELS.

By W. ROUTLEDGE.

The writer has under his charge two winding-ropes, Lang-lay, 6½ inches in circumference, having, according to the makers, a breaking strain of 200 tons. Many tests have shown that the breaking-strain, as given by rope-makers, is not always realized, and that an allowance should be made. The working load of the above-mentioned ropes is 18 tons, under the capels.

The class of capel formerly used is shown in figs. 1 and 2 (plate iii.). It was formed with a recess, 10 inches long, and the wires were turned back, and five hoops driven on in the usual manner. No. 1 experiment (Table I.) shows the results of tests made on this capel and rope. This experiment, recording surprizing results, proved that the margin of safety was by no means great.

The writer then designed the cone capel shown in figs. 3 and 4 (plate iii.). It is a solid forging of Low Moor iron; the bore, 2 feet long, tapers from 5 inches in diameter at the larger end, to 2⅝ inches at the smaller. It is fitted with a Low Moor iron pin and roller or bobbin to carry the shackle of the detaching hook. The white-metal filling has the following percentage composition: Tin, 60; lead, 30; antimony, 9; and bismuth, 1. No. 2 experiment (Table I.) gives the results of tests made on a rope, 6½ inches in circumference and with a breaking strain of 200 tons, fitted with this capel. The writer attributes the low breaking strain obtained to the impossibility of maintaining the twist and lay of the rope, as would be the case in a piece of considerable length.

In order to ascertain what effect the heating of the wires by contact with the molten metal had upon their strength, it was decided to test 28 wires which had been subjected to heating against 28 wires, taken from the same rope, which had not been

TABLE I.—TESTS OF WINDING-ROPES AND CAPELS.

No. of Test.	Description of Capel.	Details of Winding-ropes. Circumference.	Weight per Fathom.	Strands. No. of Strands.	No. of Round Wires.	Diameter of Wires.	Total Number of Wires.	Hemp Core.	Stress on Rope. Tons. 5	Tons. 10	Tons. 20	Tons. 30	Tons. 40	Tons. 45	Tons. 50	Tons. 60	Tons. 70	Tons. 80	Tons. 100	Tons. 120	Tons. 140	Maximum Stress.	Total Elongation.
									Elongation of the Rope on the Tested Length.														
		Ins	Lbs.			Inch			Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Tons.	Ins.
1	Round winding-rope, 50 inches long, with ordinary capel (figs. 1 and 2, plate i.) attached at one end.	6·40	?	6	12 8 7	0·138 0·113 0·062	162	main	—	zero	—	0·10	0·12	0·16	0·20	0·30	0·75	0·78	—	—	—	—	—
														Move	ment	of the	rope	in the	capel.				
									—	zero	—	none	0·05	0·10	0·21	0·74	6·20	7·70	—	—	—		
2	Round winding-rope, 100 inches long, with cone-capel (figs. 3 and 4, plate i.) attached at one end.	6·60	?	6	12 7	0·142 0·140	114	?	—	zero	0·12	—	0·50	—	—	0·80	—	1·05	1·38	1·80	2·40	145·80	2·75
														Move	ment	of the	rope	in the	capel.				
									—	zero	none	—	0·10	—	—	0·14	—	0·15	0·17	0·20	0·23		
3	Round winding-rope, 100 inches long.	6·60	41·0	6	12 8 7	0·141 0·113 0·064	162	main	zero	—	0·33	—	0·62	—	—	0·93	—	1·20	1·46	1·88	2·29	169·20	3·95
4	Round winding-rope, 100 inches long.	6·35	40·7	6	12 8 7	— — —	162	main	zero	—	0·12	—	0·32	—	—	0·49	—	0·68	0·99	1·30	1·82	160·18	3·58

REMARKS.—(1) The rope pulled rapidly out of the capel with a load of 59·5 tons, and the first wire broke inside the capel with a load of 70 tons. The load was gradually increased to 84·10 tons, several more wires broke at the point where they were bent back, and the rope was pulled through the capel with a decreasing load.

(2) The first wire broke with a load of 137·40 tons; and, with a load of 145·80 tons, three strands, and wires in one of the remaining strands, broke together, principally close to the front end of the capel. The remainder of the rope was then broken, and the wires in the last strand broke principally at a distance of 5 feet from the front end of the capel.

(3) No. 3 winding-rope was slightly worn: four strands broke together clear of the fastenings.

(4) No. 4 winding-rope was considerably worn, and some of the wires were found broken before the test was made: three strands, and wires in the remaining strands, broke together clear of the fastenings.

in contact with molten metal. The results of these tests, detailed in Table II., show that the heat, to which the wires had been exposed, had little or no effect upon their strength.

TABLE II.—TESTS OF WIRES FROM A NEW WINDING-ROPE AND FROM THE INSIDE OF A CONE-CAPEL.

No. of Test.	(a) Wires from a New Winding-rope.		(b) Wires from the inside of a Cone-capel.		No. of Test.	(a) Wires from a New Winding-rope.		(b) Wires from the inside of a Cone-capel.	
	Breaking Strain.	Diameter of Wires.	Breaking Strain.	Diameter of Wires.		Breaking Strain.	Diameter of Wires.	Breaking Strain.	Diameter of Wires.
	Pounds.	Inch.	Pounds.	Inch.		Pounds.	Inch.	Pounds.	Inch
1	4,011	0·140	4,200	0·140	15	4,095	0·140	4,137	0·140
2	3,780	0·139	3,948	0·139	16	3,906	0·139	4,158	0·140
3	3,969	0·140	3,906	0·139	17	3,948	0·139	3,990	0·140
4	4,095	0·140	3,990	0·140	18	3,192	0·136	3,927	0·139
5	3,864	0·139	3,885	0·139	19	3,990	0·139	3,885	0·139
6	3,948	0·139	3,864	0·139	20	4,221	0·140	3,864	0·139
7	3,990	0·140	4,053	0·139	21	3,948	0·139	4,053	0·140
8	4,074	0·140	4,074	0·140	22	4,116	0·140	4,158	0·140
9	3,906	0·139	3,864	0·139	23	4,158	0·140	3,885	0·139
10	3,990	0·139	4,011	0·139	24	4,032	0·140	3,990	0·139
11	3,940	0·140	3,990	0·140	25	4,074	0·140	4,032	0·140
12	4,053	0·140	4,011	0·140	26	4,158	0·140	4,074	0·139
13	3,099	0·140	3,885	0·139	27	4,158	0·140	4,053	0·140
14	3,927	0·139	3,948	0·140	28	3,927	0·139	4,158	0·140

The first cone capel (figs. 3 and 4, plate iii.) used for winding was fitted to a rope which had been in active service for 20 months. This was a Lang-lay rope, 6·60 inches in circumference, composed of wires drawn to a breaking strain of 110 tons per square inch, the number and diameters of the wires being as follows: 72 wires, each 0·141 inch in diameter; 48 wires, each 0·113 inch in diameter; and 42 wires, each 0·064 inch in diameter. After three months' work, severe twisting was noticed in the neck of the capel, and on close examination a whole strand was found to be broken at that point. The rope was then re-capped in a similar manner; but, after three months' further wear, severe twisting was again observed, and the rope was then removed and replaced by a new one.

Two theories are suggested as the cause of these failures:—(1) They might be due to the molten metal softening the wires; or (2) to fatigue of the wires, at the neck of the capel, set up by the bending movement at that point, arising from the swaying of the rope, which occurs during winding, the wires having become hard from being in use for so long a time. The writer is of opinion that steel-wires in winding-ropes do become harder,

as the rope is used, especially in downcast-shafts. Considerable heat is generated by friction during winding; and, after winding ceases for the day, the temperature is reduced, especially during frosty or rainy weather. In upcast-shafts, the ropes assume the temperature of the shaft, which may range from 50° to 100° Fahr. Further, when the winding-engine is not in use, certain portions of the ropes are exposed to varying temperatures, which must considerably affect the wires.

In the course of manufacture, a round winding-rope, in its passage from the laying machine to the reel upon which it is wound, receives a large amount of what may be termed unnatural twist. The question arises as to whether this twist should be released when a new rope is put into use for winding, or does the release of this twist in any way shorten the life of the rope? In many cases, it is essential to take out the twist in order to avoid serious damage to conductors and cages. Some rope-makers advise that the twist should be removed gradually, and suggest that it should be let out at the pit-bottom. The general practice is to let out of the rope as much unnatural twist as possible and to continue this during the whole life of the rope. The writer has known a rope to lengthen from 10 to 15 feet by taking out the twist at one operation, without any detrimental results.

Nos. 3 and 4 experiments (Table I.) record the results of tests of lengths cut from old winding-ropes which had been in use for 2 years.

Figs. 5 and 6 (plate iii.) are a plan and elevation of a bridle for connecting the cage-chains to the capel. This bridle is made of a bar of Farnley iron, 3 inches square, turned into the requisite shape, and welded at the bottom-side. In this way, the grain of the iron is continuous, and a strain exerted in any direction cannot pull in the same direction as the grain of the iron.

Mr. W. Walker (H.M. Inspector of Mines) asked what method was used in fitting the rope into the capel with molten metal. With regard to the theory that molten metal might affect the temper of the wires, the results recorded in Table II. showed the opposite. Referring to the constitution of the white-metal

filling, he (Mr. Walker) stated that lead fused at a temperature of 617° Fahr., bismuth at 507° Fahr., tin at 442° Fahr. and antimony at 797° Fahr.; but a mixture of two parts of bismuth and one part of tin fused at about 212° Fahr. If, therefore, the addition of bismuth lowered the melting point, the temperature of the alloy in the capel must be below 797° Fahr. Galvanized winding-ropes were used, and he (Mr. Walker) understood from the makers of such ropes that the temperature required to galvanize successfully the wires was more than 800° Fahr., and frequently exceeded 1,000° Fahr.; and if this were the case, it could hardly be said that the molten metal affected the temper of the wires.

He (Mr. Walker) also asked whether the writer had ascertained if the solid capel was completely filled with metal. In some instances, clay was used to prevent the molten metal from running through; and, when it was taken out, an edge was left on the top of the capel over which the wires were continually bending. Another point was, that in taking out the hempen core of a rope it was necessary to see that the wires of the strand were closed and properly treated; otherwise a hollow space was left in the interior of the strands.

Mr. H. Ingold said, with regard to the second test, that it would be interesting to know whether the rope had been tested and with what result, and what length of capel was used at the other end. He imagined, if the rope was tested at a testing-works, that the length of the capel, at the other side, would be 7 inches. He had tested many hundreds of ropes, and in no case did the length of the capel exceed 5½ inches. For winding, it was necessary to give an ample margin of safety, and he recommended that the barrel of the capel should be 15 inches long with a rope 1½ inches in diameter, and 24 inches long for ropes exceeding 1½ inches in diameter.

Mr. R. Routledge held the same opinion as Mr. Walker, and did not think that the molten metal would damage the wires of the rope. Solid capels were not new to him. He returned from America in December, 1873, and solid or bell capels were then in use at the pits under his charge. At one pit, the same winding-ropes with solid capels had been used for six years previous to his taking charge, and were still doing duty when he left two years

later. Since his return to England, he had used solid capels continuously for haulage-ropes. In his experience, if a solid capel were put on properly, it might burst, but the rope could not be drawn through it.

Mr. Isaac Hodges said that he would like to say a few words for the old form of hooped capel. After reading Mr. T. W. H. Mitchell's paper* some time ago, giving remarkably low figures for the efficiency of hooped capels, he (Mr. Hodges) decided to test the margin of safety at the end of the life of the winding-rope, when the margin would naturally be the least; and to that end a length of worn-out winding-rope, 6 inches in circumference, with a 6 months' old capel attached, was taken to Leeds University for a test. He thought that such a test of a discarded winding-rope and capel was more nearly what colliery managers desired, rather than a new winding-rope with a capel specially attached for the purpose of the test. This winding-rope, when new, had a guaranteed breaking strain of 138 tons; and, bearing in mind Mr. Mitchell's figures, he supposed that after a life of upwards of three years it would have broken at less than 100 tons, and that the old capel would have been pulled off at much below that strain. He was glad to report that the rope stood a strain of 100 tons without breaking and that the old capel remained quite secure; it was the new white-metal capel put on the other end of the rope, for the purpose of the test, that failed. In reporting on the failure, Prof. John Goodman stated that "this points to the fact that the white-metal end, on the first sample of rope, was unskilfully prepared, which was due to the fact that the man who prepared the end bent all the outer wires at a sharp angle during the cleaning process." In a second test, the rope, the hooped capel, and the white-metal capel stood a strain of 100 tons (the highest strain that could be applied by the testing-machine at Leeds University) without a sign of failure. There are some points about the hooped form of capel which were preferable to the white-metal capel, as the hooped capel might sustain a shock, causing considerable slip, that would be quite obvious to any examination; it would still, however, leave that form of capel of undiminished strength, whereas the white-metal capel showed no signs of distress before giving way. He was

* "Notes on Capels for Winding-ropes," by Mr. T. W. H. Mitchell, *Trans. Inst. M. E.*, 1905, vol. xxix., page 173; and 1905, vol. xxx., page 239.

also of opinion that white-metal capels, to be efficient, must be applied very carefully and only by experienced men.

It was stated by Mr. Routledge that the breaking strain of the winding-rope, 6½ inches in diameter, was 200 tons; but he should like to know how this figure was arrived at, as he thought that it was far in excess of the breaking strain of the highest class of rope from the best makers. He was compelled to think that the breaking strain given was calculated from the aggregate breaking strain of all the wires; but it could never be that the whole of the wires in one rope would bear exactly a proportionate strain, and that they would all break at the same instant. He had found it a good rule to deduct 15 per cent. from such a calculated strength, and, in the examples given by the writer, it would mean a breaking strain of about 170 tons, which more nearly approached the actual breaking strain that the rope had given during the tests. He thought it was highly desirable, when colliery managers were speaking of the strengths of winding-ropes, that they should mean a strength which might reasonably be expected to be obtained in a practical test, rather than a strength that only existed on paper. To illustrate that point, he might instance, as compared with the breaking strain of 200 tons for the ropes, 6½ inches in diameter, mentioned by Mr. Routledge, that ropes, 6½ inches in diameter, supplied by wellknown makers to the largest pit of the Whitwood collieries, comprizing six strands of 19 wires of No. 9½ gauge, with a breaking strain of 120 tons per square inch, had a calculated breaking strain of 193 tons, but they were guaranteed and spoken of as having a breaking strain of 164 tons.

Mr. W. T. Cheesman agreed with Mr. Hodges as regarded the breaking strain, for he considered that it was misleading to quote the aggregate breaking strain of the wires; as an allowance should be made of 5 to 50 per cent., according to the construction of the rope. In the ropes quoted, there should be an allowance of 15 per cent.

Mr. M. H. Habershon said that, in the discussion on Mr. Mitchell's paper, he had mentioned a method of capelling a winding-rope in the old way, but without turning the wires back.* The hempen core was cut away for a length of 3 or 4 feet; the

* *Trans. Inst. M. E.*, 1905, vol. xxx., page 244.

strands were replaced in position, around an iron plug or cone; and the intervening spaces were filled by inserting separate, short pieces of strands. The solid cone, thus obtained, was tightly wrapped with binding wire, and then placed inside an ordinary capel. He believed that this method of capelling had been used at some of the large collieries in South Wales. A capel, made in this way and tested at the Sheffield testing-works, had been found stronger than the rope. He thought that it was a mistake to turn back any wires, as in the ordinary form of capelling.

Prof. G. R. THOMPSON said that the example quoted by Mr. Isaac Hodges must not be taken as proving the failure of the system of capping with white metal. Mr. H. Ingold had pointed out the wide margin ot safety in the capping described by Mr. Routledge, stating that in testing such a rope a length of only 7 inches of white metal would be used, against the length of 17 inches provided by Mr. Routledge. The recorded failure should be taken as indicating the lowest margin to which the length of white metal could be reduced, the length in that case being little more than 4 inches. It should be understood that the testing cones were designed for much smaller ropes, and that the effective length of the socket had been reduced so as to enable larger ropes to be tested, indeed the rope mentioned by Mr. Hodges was far beyond the testing-power of the machine (100 tons). Even under these conditions, the white-metal capping yielding 70 per cent. of efficiency compared favourably with the ordinary forms.

Mr. W. ROUTLEDGE, replying to the discussion, said that the winding-rope, referred to by Mr. W. Walker, was wrapped with soft binding wire for a length of 4 to 6 inches, at the neck of the capel, and a pair of tight-fitting clams were fixed to the wires to stop the rope from unlaying. The wires, when opened out, were thoroughly cleaned with emery-paper, and the capel was placed in position about 6 feet from the ground, in order that the rope should not be too suddenly bent. The capel was then filled completely with white metal: powdered resin being used as a flux. In the second test (Table I.), the rope, 100 inches long, was fitted with a cone capel 2 feet long on one end and 9 inches long on the other.

No one had discussed the questions (1) whether the natural twist in a new rope should be liberated when the rope was fitted in the shaft, and (2) whether it in any way shortened the life of the winding-rope. He would be very pleased to hear the opinions of members on these points.

DISCUSSION OF MR. O. SIMONIS' PAPER ON "LIQUID AIR AND ITS USE IN RESCUE-APPARATUS."*

Mr. W. E. GARFORTH said that the members were much indebted to Mr. H. Simonis for the exhibition of the aerolith, and for the lucid explanation that he had given of the apparatus. The question of rescue-work in mines was most important; and the members would be pleased to give Mr. Simonis the benefit of their practical experience as to how the apparatus could be adapted to underground roads, as he was personally prepared to do. He had received an aerolith apparatus, and after it had been tried in the test-gallery he would report the results to the members. He asked Mr. Simonis whether he had any experience as to the effect of the cold air on the wearer of the apparatus, who might become very hot whilst working, say, at a gob-fire. He noticed that part of the vitiated air returned through a short length of pipe and to that extent was, therefore, in contact with the main supply of good air. It struck him that the vitiated air might accumulate in some way, and have a deleterious effect upon the wearer. He might mention that, three or four years ago, an underground fire occurred at a Lancashire colliery; and, in extinguishing it, he and others worked in a temperature of 157° Fahr. If this apparatus were used under such conditions, would not the evaporation of liquid air take place at a greater rate than the wearer's requirements? And supposing that during exploration-work in a heated roadway, the explorers had to wait for, say, an hour owing to the roof falling, would there be sufficient air to return to the shaft?

Mr. H. SIMONIS said that men had worn the apparatus in the presence of doctors, who had taken measurements of pulse and respiration, and they had not found that the wearers had suffered

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 534; and 1907, vol. xxxiii., pages 2 and 170.

any ill effects from breathing the air, which had acquired sufficient heat as it passed through the tubes. The apparatus had no ill effect whatever for a period of 2 or 3 hours, in fact, he maintained that a man could, under ordinary conditions, do better work, breathing from this apparatus than breathing normally, because of the greater percentage of oxygen in the evaporated air. The apparatus was primarily constructed for use at mine-fires and the influence of large variations of temperature on the liquid air was counteracted by the complete isolation of the liquid-air receptacle. The aerolith had been used by the London Fire Brigade on several occasions; and in a cellar-fire, where the firemen had to creep to get at the fire, it worked very well.

The discussion was adjourned.

THE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
JULY 29TH, 1907.

MR. A. M. HENSHAW, PAST-PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

MEMBERS—
Mr. E. M. FOX, Westwood Manor Coal-and-Iron Company, Wetley Rocks, Stoke-upon-Trent.
Mr. CLEMENT HENSON, 103, Corporation Street, Stoke-upon-Trent.
Mr. ST. V. CHAMPION JONES, Lilleshall Collieries, Shropshire.
Mr. J. H. LISTER, Woodhead Colliery, Cheadle, Stoke-upon-Trent.

ASSOCIATE—
Mr. W. T. E. MALBON, 201, Leek New Road, Cobridge, Burslem.

The officers for the ensuing year were nominated.

DISCUSSION OF MR. ST. V. CHAMPION JONES' PAPER ON "A GOB-FIRE IN A SHROPSHIRE MINE."*

The CHAIRMAN (Mr. A. M. Henshaw) thought that they had had further trouble with the gob-fire at the Lilleshall collieries.

Mr. F. H. WYNNE said that he had not heard about it.

Mr. J. T. STOBBS said that he could not allow the statement to go forth unchallenged, that the Lilleshall Hill was an intrusive rock and that it caused the bending of the measures of

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 78.

the Coalbrookdale coal-field. The measures were shown in the diagram* as curved, but that bending was not caused by the intrusion of the Lilleshall Hill, for the simple reason that Lilleshall Hill existed ages before the Coal-measures were deposited. Part of it consisted of the Hollybush Sandstone, faulted against Uriconian rocks. The Hollybush Sandstone was of sedimentary origin, and therefore it was quite erroneous to describe Lilleshall Hill as an intrusion. Further, it was equally wrong to say that this hill caused the bending of the Coal-measures, because as he (Mr. Stobbs) had pointed out, Lilleshall Hill was geologically a very old hill. It was older than the Coal-measures by a longer period than the Coal-measures were older than recent deposits.

DISCUSSION OF MESSRS. W. N. ATKINSON AND A. M. HENSHAW'S PAPER ON "THE COURRIÈRES EXPLOSION."†

Mr. E. O. Simcock said that first causes should be studied just as much as, or more than, aggravating causes. Without cause there would be no effect, and if first causes were clearly known and avoided or minimized, there would be fewer extensive disasters. Considering this, and not being prepared to concur with the principal theory of causation put forward, he would like to state his reasons; but, before doing so, he wished to state that he quite believed that the evidence showed conclusively that the explosion was propagated by coal-dust and that there was no evidence of fire-damp being present, at least, in quantities not negligible. His experience of sudden outbursts of fire-damp in the presence of naked lights led him to believe that this did not necessarily involve an explosion, or even firing of the gas, so he considered that the theory of sudden outbursts was out of the question. In the face of facts accumulated during the past 30 years there could be very few mining engineers who disbelieved that coal-dust alone would propagate an explosion. Coal-dust was always with them, and as coal-cutting machines came into more general use, coal-dust would be found in places now considered practically free. These places were the faces

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 84, plate i., fig. 2.

† *Ibid.*, 1906, vol. xxxii., pages 439, 340 and 507; and 1907, vol. xxxiii., pages 124, 303 and 326.

where these machines are used. The problem of how to deal with coal-dust on haulage-roads was difficult to solve, but it would be an easy one in comparison with the problem of dealing with coal-dust at the face. In all accounts of experiments on coal-dust that had come under his notice some of the coal-dust had always been put in suspension in the air. It would seem that if the coal-dust was not in suspension it would not explode; and personal experience told him that coal-dust in suspension would not, necessarily, explode at a naked light in a place at a temperature of 100° to 150° Fahr. So that, to have a coal-dust explosion, there must be a high-temperature detonation while coal-dust was in suspension, or a high-temperature detonation so prolonged in the presence of coal-dust, that it would stir up the dust and then fire it.

The starting-point of many explosions had been traced to the vicinity of a shot which had been fired at the time or immediately before the explosion. The natural inference had been that the shot was the immediate cause; but was this so in the case under consideration? Two theories had been put forward to account for the cause of the explosion:—(1) The fire in the Cécile seam; and (2) the shot in the Lecœuvre heading. All the evidence that had been collected seemed to prove that the shot was the first cause; but, after carefully sifting the evidence, the conclusion seemed irresistible that, whether the fire caused it or not, there was less probability of the shot causing it.

The facts put forward in connection with ignition by the shot were:—The remainder of the shot-hole, 20 inches deep, was shattered in its interior, 4 inches in diameter at the mouth, with dust and fine coal inside. There were signs of cutting with a pick near the hole.* The hole pointed approximately towards the fourth air-pipe, which was blown to pieces. Similar holes had been seen in the pits before, and there was one similar in the parallel heading. As similar holes had been seen and another had been found, then if the theory of causation were true, it must have been a practice to cut out missed shots with the pick at these collieries, but there was nothing put forward to show that this was so. If a hole, 20 inches long, in strong coal, was charged with 1 pound of explosive and fired, the mouth of the

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 270.

crater would be more than 4 inches in diameter, and it was not probable that any fine coal or dust would be left behind; nor could any fall into it after the firing of the shot, unless the hole were pointing upwards and was low down. The fourth air-pipe, which was about 33 feet (10 metres) away, and lying at an oblique angle to the line of shot, was practically blown to pieces, yet in No. 19 experiment,* a similar air-pipe, placed with its centre 23 feet (7 metres) from the cannon charged with 17·6 ounces (500 grammes) of No. 1 Favier powder, with dust in suspension in the air and dust on the floor, was not destroyed but only knocked down and slightly damaged at the end. Air-pipes were in constant use in many headings and cruts, where shot-firing was carried on; but he doubted whether anyone had ever seen an air-pipe damaged to such an extent as the result of shot-firing, no matter how the air-pipe was arranged. However, the pipe was destroyed, and it showed evidence of great violence.

The remainder of the shot-hole, 20 inches deep, 4 inches in diameter at the mouth, was shattered in the interior. Many mining engineers had seen somewhat similar holes during the course of their experience, especially before No. 127 Special Rule (which refers to coal being properly holed, cut and dressed), interpreted to mean that a hole should not be put in beyond the holing, was strictly enforced. This hole appeared to be the remainder of a shot-hole that had been drilled beyond the holing, and, as usual in similar cases, part of it was left. There was a belief amongst "old men" of this country that such a shot helped them considerably in their work; and, from the fact that these holes were common at Courrières collieries, it appeared that they had the same belief over there. If this hole was a similar hole to the others, then naturally, it was made in a similar way; and as the others were the remains of holes that had partly done their work, then this also had partly done its work and not just blown out. This was borne out by the shattered condition of its interior. Blown-out shots usually showed no signs of shattering, especially at this depth—20 inches.

There were signs of cutting with a pick against the hole. This was a recess a foot wide, above and to the right hand of the hole. Special notice should be taken of this, for if this recess

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 486.

were made before the shot went off, then the explosive acted in a very peculiar manner, for although it was powerful enough to shatter the interior and to make the mouth 4 inches in diameter, to travel 33 feet (10 metres) and then rend a sheet-iron air-pipe to pieces, yet it was unable to break through the small rib of coal between the hole and the recess. The recess was to the right of the hole: consequently a left-handed man must have been cutting it, or, if right-handed, he would have been standing directly in front of the hole, and in that case the force and flame would have been spent upon him. These two facts showed that the recess was made after the shot was fired, and tended to prove that the men were dressing off the loose coal and squaring up generally. The fine coal and coal-dust in the hole were evidence of this, for they could have got in by no other means.

The quantity of coal in the tubs between the pit and the heading, and lying at the face, was also evidence that the shot had partly done its work, as hand-labour would not account for that quantity under the circumstances, and there would be no necessity to work off the whole face to cut out the shot. The actual contour of the face could not be known, but an approximation could be arrived at. There were 8 tubs of coal between the pit and the face, with about 4½ tubs lying at the face; some might have gone up the shaft as the pit had been drawing for 2 hours, but this would not be taken into consideration. Taking the quantity of tubs given, and allowing 8 cwts. to a tub, the quantity of coal would be 5 tons: and this, allowing 80 pounds per cubic foot, would equal 140 cubic feet. The place was 7 feet 6 inches high and 9 feet wide, and if the average height of the holing was 6 inches, an area of 63 square feet was left. This area, divided into 140 cubic feet, showed that a length of nearly 27 inches had been removed; and that (27 + 20 or) 47 inches was the original depth of the shot-hole. The amount of 27 inches got off the face, if got off by hand-labour, would represent a very good 1½ hours' work, which would be about the time that these men had been working. A length of 2¼ feet would be a fair ½ day's work in a shoulder-cutting, and there was no conceivable reason why these men should work with such haste, especially when the fact was taken into consideration that there was a machine-drill at hand which would have enabled them to put in another hole quite as deep in, say, 20 minutes, and could have been charged and fired within ½ hour; or, if their minds were a

little perverted, as suggested by the theory under consideration, then they would have tried to unram the shot instead of cutting it out: for anyone doing wrong will do it in the quickest way, so as to leave less likelihood of being caught in the act.

The positions and injuries of the men found in this heading did not bear out the theory of causation put forward. Three bodies were found lying on the coal at the face deeply burned, and one 62 feet (19 metres) outbye minus a leg and arm, which were found 10 or 13 feet (3 or 4 metres) further outbye. Here was indubitable evidence of force moving outwards, but the bodies lying on the coal negatived the idea of force from the face. These men were deeply burned, but nothing was said as to their being mutilated, and the fact that they were found lying against the face showed that whatever force acted upon them did not force them outwards, but inwards, as it was improbable that all the three men would be working on the top of the coal.

If the fine coal and the coal-dust seen in the shot-hole did not get in as stated, then it was not impossible for them to have been driven thither by an inward force. Nos. 1, 2 and 3 air-pipes were moved inwards. The machine-platform was blown inwards, and a board therefrom blown further inbye. This board was undoubted evidence of a force moving inwards, just as the arm and leg were of a force moving outwards. In the view of the face of the heading,* the timber had been blown inwards and showed an inward force. There was evidence that the tub was found damaged against the face, yet in No. 19 experiment a similar tub, not in the direct line of the shot, was projected outwards over 33 feet (10 metres) and partly destroyed. Nothing was said about the cause and nature of damage to the tub found in the heading, but he ventured to think that an inward force was the cause of the damage, and that the greatest damage was found at the outbye-end of the tub. These facts negatived the idea that the shot caused the explosion; and, if there was not evidence of another cause, then, in default, the fire would be blamed.

It was true that the story of that unfortunate morning might never be reconstructed from ascertained facts; but in all well-managed collieries a great amount of work became routine, and from this the approximate truth might be ascertained. The data given were fairly complete, and from these details the story, to a

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 469.

great extent, could be gathered. If anyone had been working in this heading between Friday afternoon and Saturday morning there would have been some record of it, so it might be assumed that it stood during that period. As they were using a holing-machine, no shoulder-cutting would be in operation, especially if the heading was working on one shift only, for one man cutting could not keep up with a machine, so that the machine was probably used for shearing or cutting as well as holing; but, as it was set upon a platform and not on a pillar, it was not likely that the shearing had extended to the roof. Four men worked in the heading, and it was probable that their work would be apportioned as follows: two would attend to the machine, one man would flitch or dress the sides and attend to the timbering, and one would load. No missed shot was reported on the day preceding the explosion, and it was not likely that these men would leave a missed shot unreported, on account of the examiner seeing it and causing trouble. Thus, what really occurred would probably be as follows:—On Friday, at knocking-off time, these men had not got a dressing quite finished, but the machine, etc., would have to be taken back from the face. On the Saturday morning, instead of putting the machine in again and finishing the dressing, they would decide upon a shot, perhaps to give them a start, or because the air-pressure was too low to work the machine. Putting in the hole, charging and firing it, would occupy them till nearly 6 a.m. The 8 tubs on the road would about represent what had been loaded between that time and the explosion, which occurred a few minutes before 7 a.m.

All available data pointed to the explosion starting in this heading, and it showed force inwards to the face and outwards at 62 feet (19 metres) from the face, with evidence of very strong force at 33 feet (10 metres) from the face; and thus clearly indicated the exact spot from which the explosion commenced. There would be only one thing that could start an explosion from this spot, and that would be the explosives that the men had with them. No other explanation would account for No. 4 air-pipe being so seriously damaged. To be told that the whole of the explosives served out to these men on that morning were found in the can, at the entrance to this heading, would altogether seem to discount any theory based upon a "premature explosion of the explosives" as the initial cause; but when one fact appeared to

be opposed to a long train of facts and deductions, it invariably proved to be capable of bearing some other interpretation.

In the report under discussion the theory of causation rested upon the assumption of an unreported missed shot, and this in a colliery which seemed to have been very ably and carefully managed; but, as had been shown, there were many things inconsistent with the missed-shot theory. It was practically impossible that there was any missed-shot, as the amount of work done could not be accounted for by hand-labour and it was consistent with what would approximately have been done by a shot. Notwithstanding the fact that the whole of the explosives served out to these men that morning were found, there was strong presumptive evidence that a shot had been fired that morning, and the shattered condition of the hole was direct evidence that a shot had been fired. If a shot had been fired and yet the whole of the explosives were found, then there was *primâ-facie* evidence that these men were in possession of more than one can of explosives. The rules in respect to explosives were similar to our own: the General Rule, under the Coal-mines Regulation Act, which would apply, was 12*c*, which enacts that "a workman shall not have in use at one time in any one place more than one of such cases or canisters." That is: "one man one can"; but "one man one can" did not mean "one place one can"; for if A is in charge of a can and works in a *barut*-drift,* B also being in charge of a can and working in the same drift, neither can be said to be disobeying the rule for each have only one can in use "at one time in any one place." This might seem to be labouring the point, as something which would never occur in practice; but, let them take a case which might occur in any colliery, and did occasionally occur in every colliery where, owing to absentees, there was a shortage and men from one working-place were drafted to other places to fill them up. In such cases, what became of the powder-cans? The answer is obvious, for the men were not allowed to leave them in their own working-place.

Something similar might have occurred in the case under discussion, for the parallel heading was not working on that day; and when working, explosives were used there. Thus,

* *Barut* is the Hindustani word for explosives, and as working-places or drifts are usually given names, in putting forward the hypothetical case in which the word is used, it struck the speaker as being an appropriate one.—E.O.S.

two cans in a place were easily accounted for, and one can of explosives being found did not invalidate the theory that the initial cause was due to a can of explosives prematurely exploded. It might be said that explosives would not be put in such a position, and if put there, how came they to be fired? The first contention was easily answered. A holing-machine was being used in this heading, and therefore it would be travelling fairly rapidly; whereas by ordinary hand-labour in such a heading perhaps, one, two, or at most three shots would be fired in a shift; in this case, probably not less than six shots, at intervals, would be fired, and the explosives would be kept close at hand. This would be about 36 feet from the face, and he had seen explosives as near as that to the face in this country.

How the explosives came to be fired was another question. Something falling on them might have exploded them, but this was doubtful, as they would be put in a position reasonably secure from falls. It was significant that this place was in a line with the last shot fired, and as it was partly blown out, the stemming and some of the fuze would strike there. This might drop down at the back of the air-pipe, and when the men returned the powder-can would be placed in its vicinity. Nothing unusual would be noticed at the time, for the place would be full of smoke from the shot, and any smoke or smell from this fuze, after the place had been cleared, would travel close to the air-pipes and be drawn into them before giving anyone much chance to detect it. It might be contended that there would not be enough fire left in the fuze, to start the coal-dust smouldering, but Messrs. W. N. and J. B. Atkinson* say that the "snot" of a lamp thrown amongst it would fire it, and he (Mr. Simcock) had had personal experience of a piece of fuze from a shot starting a fire in a mine through coming into contact with nothing but coal-dust and fine coal. It might be contended that the explosive would not explode under the conditions laid down, but a moment's serious thought would show the fallacy of such a contention, even if no detonators were present; for the causes of various tragedies occasionally reported in our newspapers, through colliers taking explosives home and putting them in the oven to "thaw," were due to, practically, the same conditions. He had no practical experience of No. 1 Favier powder; but ammonium nitrate

* *Explosions in Coal-mines*, page 22.

was not always a stable compound, and practical experience told him that many high explosives seemed to have a critical temperature, and so far as lighting was concerned, behaved like ordinary powder at and beyond that temperature. For instance, dynamite required no detonator if the prevailing temperature was 75° Fahr. or upwards.

Briefly, the story of that morning, so far as the Lecœuvre heading was concerned, would be: No coal down and the place only partly dressed; no air-power to work the holing-machine; or as the men would not go to the trouble of putting it in to take it out again shortly, they put a shot into the partly dressed face. This shot, being partly in the solid, besides getting some of the coal down, would blow the stemming and some of the burning fuse outwards in a straight line towards No. 4 air-pipe. When the men returned, after the shot had gone off, a powder-can was placed in close proximity to where the burning fuse had fallen. This was not observable, owing to the smoke, and was not detected afterwards, as any smoke or smell arising was carried along close to the air-pipes and drawn into them. The burning fuze started the dust smouldering; this heated the contents of the can to exploding point in about an hour, and the explosion of these started the dust.

Mr. F. E. Buckley said that it was not possible for anyone to say what length of wetted area was necessary to stop an explosion, as it depended upon the quantity of dust involved in the explosion and upon local circumstances. It might be said that 300 or 600 feet thoroughly moistened would prevent the propagation of an explosion; but, in his opinion, unless they knew the actual conditions of every pit, no one could say what length of wetted area was necessary; a length of ½ mile might be wetted and the explosion might, under certain conditions, even then travel over it.

The Chairman (Mr. A. M. Henshaw) said that, in his opinion, a length of 300 feet, if properly wetted and freed from dust, was sufficient to stop an explosion of coal-dust.

The discussion was adjourned.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
JUNE 11TH, 1907.

MR. CHARLES PILKINGTON, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—
Mr. GREGORY RABY, Mining Engineer, Lota Alto, Lota, Chile.
Mr. SHERWOOD HUNTER, Mechanical Engineer, 20, Mount Street, Manchester.

DEATH OF MR. MARK STIRRUP.

Mr. JOSEPH DICKINSON said that the late Mr. Mark Stirrup was one of the oldest and most useful of their geological members. Mr. Stirrup held the post of honorary secretary of the Society for about ten years, and was elected an honorary member in the year 1904. He (Mr. Dickinson) moved that the members express their regret at Mr. Stirrup's death, and that a letter of condolence be sent to his relatives.

Prof. W. BOYD DAWKINS, in supporting the proposal, said that he experienced great difficulty in speaking about Mr. Stirrup, because of the friendship which existed between them. Mr. Stirrup was one of his oldest and best friends in Manchester, and they made many geological expeditions together, both in this country and on the Continent. He (Prof. Boyd Dawkins) felt that the Society had suffered a very great loss. Mr. Stirrup was a very high type of a man, and he did not think that any man could make him swerve in the slightest degree from what he considered to be the truth. He died in the fullness of years, and had left his mark on the science of his time.

The motion was adopted in silence: the members standing.

Mr. G. G. L. PREECE read the following paper on "Recent Improvements in the Design of Electric Cables for Collieries":—

RECENT IMPROVEMENTS IN THE DESIGN OF ELECTRIC CABLES FOR COLLIERIES.

By G. G. L. PREECE, M.Inst.M.E., A.M.I.E.E.

In connection with various papers communicated to the members of mining institutions, criticism had often been made that electrical engineers, when submitting the fruits of their wisdom to practical mining engineers, dealt too much in generalities, and avoided facts. The writer had this criticism in view when preparing this short paper, and considered that if he could lay before the members definite views, without qualification, as to the best types of electric cable for use under modern conditions of electrical working in collieries, he, at least, would disarm a portion of the criticism, whilst possibly his contribution might possess some practical value. He had pleasure, therefore, in submitting to the members two recent improvements in the design of electric cables which are particularly adapted for the conditions ordinarily prevailing in collieries, and which, in his opinion, are so valuable as to result in a greatly increased efficiency and length of life compared with cables hitherto designed and manufactured for colliery-purposes.

I.—The first improvement in cable design is not an entirely new type of cable, but a special feature in connection with the basis of all insulated electric cables, namely, the stranded copper conductor. The speciality is called "the patent solid strand-filling,"* and consists of the filling of the interstices between the wires composing the strand with a solid compound which will not run or become displaced by the heating of the conductor through overload. In course of manufacture the central wire, and each succeeding layer of the stranded conductor, is covered with a thin tube of plastic bituminous compound. This compound being thoroughly worked into the interstices of the strand, all capillary passages for moisture are stopped—in fact, water

* British patent, 1905, No. 4260.

cannot be forced in, even under pressure. This type of stranded conductor is particularly recommended, in conjunction with bitumen, as the insulation or dielectric.

The advantages of such a type of cable are very obvious: there is nothing of a fibrous nature about such a cable, nor anything which can possibly take up moisture, the whole cable being waterproof. The writer may state that water in the strand of a cable is harmful, and the majority of faults—indeed, the chief reason of deterioration in colliery-cables—are due to water getting into the strands of the conductor. In most collieries, the water

FIG. 1.—COMPLETED SOLID BITUMEN SHAFT-CABLE.

is more harmful than ordinary water. This water enters either through the ends or through an original fault, which in many cases may be caused by mechanical damage. It is the writer's experience that, at collieries, cable-ends are often exposed to dampness through carelessness; and, owing to the difficulty of repairing a fault immediately and properly, water has often entered the cable before a repair can take place. Neglect by the ordinary workman to inform his superiors of the occurrence of a fault or damage, and a hasty repair, made with a bit of rag or tape, come under this heading.

Once water is in a cable, actions and reactions occur, and deterioration takes place, more or less rapidly, depending, more or less, on the load of the cable and the thickness of the dielectric. It is very obvious, therefore, that any cable, particularly a bitumen-insulated cable, treated so as to be absolutely proof against such deterioration by preventing the passage of water along the strands of the conductor, must be of great value and possess many advantages; and it is almost "fool-proof" against the carelessness of employés. The extra cost of so treating a bitumen-insulated cable is small and trifling, compared with the increase in life given to the cable.

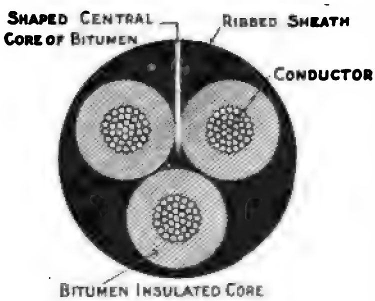

FIG. 2.—END SECTION OF SOLID BITUMEN SHAFT-CABLE.

II.—The second improvement in cable design which the writer wishes to describe is an entirely new type of cable, called "the patent solid three-core bitumen-cable."* The mode of manufacture is as follows:—The conductors of this cable are each separately insulated with bitumen compound, they are then laid together round a shaped central core of bitumen which

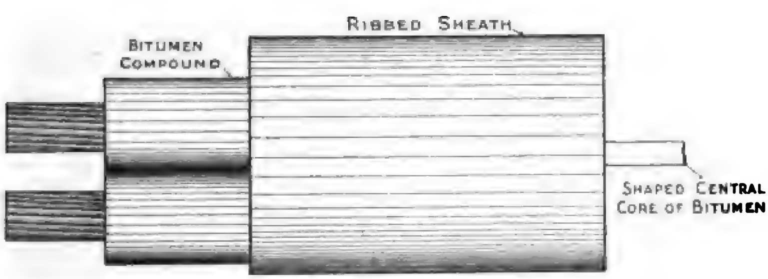

FIG. 3.—SOLID TYPE THREE-CORE BITUMEN-CABLE WITH INSULATION AND SHEATHING.

fills up the central space; and the whole is sheathed over with a solid tube of bitumen, which is forced on so as to be ribbed internally and to fit exactly the interstices between the three cores (figs. 1, 2 and 3). The cable can then be taped and protected

* British patent, 1906, No. 8238.

by armour, etc., as may be necessary. The cable being a three-core one, is used for three-phase alternating currents. Three-phase working is becoming very general in collieries; and as, for electrical reasons, apart from other reasons, the three-core cable is the best, a large quantity of such cable is used.

The special construction of the solid three-core bitumen-cable obviates the introduction of fibrous material as padding or elsewhere in the body of the cables; and, consequently, it has many advantages over the ordinary types. The ordinary three-core bitumen-cable, for instance, is composed of three cores, each insulated with bitumen compound—some types have jute-braids or tapes directly over the stranded conductor and underneath the bitumen insulation; each of the three cores are taped, with more fibrous material, and then laid up together; and, in order to make the cable into a circular form, jute-warp or other fibrous material is used to fill the interstices between the cores and in the centre. The cable is then taped and protected in the usual manner. Cables are manufactured with an outer sheathing of bitumen over the cores; but, in these cases, the jute-padding is still used in making the cable circular. In the solid three-core bitumen-cable, it will be noticed that the outer sheathing of bitumen, owing to its ribbed construction, itself fills up the interstices.

The advantages possessed by this cable over ordinary types may be described as follows: (1) Higher insulation and dielectric strength. The effective strength between each core and between the cores and earth in the case of the solid three-core bitumen cable is the total thickness of bitumen between the conductors, that is, twice the thickness on each conductor, and the total thickness of bitumen over each conductor and around the three cores respectively. This is twice the effective dielectric obtained in three-core cables of the ordinary construction, as, by the use of fibrous tapes on the insulated conductor and of jute padding, a potential earth is introduced immediately around each core, and if moisture creeps down, as is quite likely, such fibrous material becomes an earth potential. (2) Greater chemical protection against bad water, etc. This is obvious, in view of the explanation given above that there is greater effective insulation. (3) Greater reliability in wet situations. This is also obvious, as water cannot creep down the cores. This may be understood

by examining a rough sample, and noting with what difficulty the outer sheathing is wrenched away from the three cores. The cable is practically homogeneous. (4) Greater mechanical protection of the cores. This is obvious, owing to its construction. The cores in the ordinary type are fairly loose. (5) Minimum chance of decentralization due to overload. This is also obvious, owing to its construction. The ribbed sheath holds the cores in place, gripping them tightly. (6) The solid three-core bitumen-cable combines in itself all the advantages of a perfect solid system. (7) A further advantage lies in the fact that, in consequence of the cores being gripped along their whole length by the outer sheath, and thus not slipping, there should be no hesitation in suspending this type of cable (when armoured) by its own weight for a distance of 1,200 feet. The distance in practice is limited by the weight of the cable. In fact, a cable 1,200 feet long so suspended, and weighing about 5 tons, is to be installed during the next two or three weeks in a shaft near Stoke-upon-Trent. There are many advantages obvious to colliery managers, which the writer need not point out here, in being able to suspend a cable from one point at the top of the shaft.

The stranded conductors in this type of cable, which can and are used up to a pressure of 3,000 volts alternating, can, of course, be treated with the special solid strand-filling compound. This would then form, in the writer's opinion, absolutely the best cable possible for three-phase working in collieries and mines. The improvements being mainly connected with the bitumen-insulated type of cable, a few general remarks on this type of cable will be, therefore, a fitting conclusion to this paper.

The bitumen type of cable, as now designed and manufactured by the leading British cablemakers, is of so stable a nature, and so carefully and scientifically made, that the writer has no hesitation in recommending it as the best type of cable for use in collieries, at all pressures, at any rate, up to 3,000 volts. Beyond that voltage, it may be necessary to introduce a certain amount of paper with the bitumen; but in this short paper there is no scope for the discussion of special conditions.

The bitumen-compound should be tough and resilient, and designed so as to suit varying temperatures; it must not be too soft at high temperatures, nor become brittle at low temperatures.

A bitumen-cable so designed possesses great permanency and chemical inertness, and resists, very successfully, the various oxidizing and other influences met with in collieries—such as bad pit-water, etc. Some bitumen-cables are very hard, and appear very strong, mechanically, at normal temperatures; and these cables are often looked on with favour by mine managers. These physical properties are, however, obtained by the sacrifice of permanency of dielectric and chemical inertness; the hardening or stiffening usually takes the form of an addition of mineral loading-matter. Such a course renders the dielectric liable to loss of coherence in its particles, with a great tendency to become brittle and to crack at low temperatures; and, consequently, it encourages in a much greater degree the action of the oxidizing and other influences met with in colliery-workings.

Mr. T. H. Wordsworth asked whether Mr. Preece considered it advisable to use three-core cables in shafts when the power to be transmitted was, say, 250 kilowatts at 500 volts. In his experience, three-core cables for this amount of work became too heavy and troublesome to handle in the shaft. He wished to know whether the filling of the strands would entirely prevent water from creeping up the cable, as he understood that with continuous current there was always a tendency for the water to travel up the negative cable.

The President (Mr. Charles Pilkington) questioned the feasibility of suspending a three-core cable, 1,200 feet long, without risk of serious injury. He had had some experience with electric cables, and knew how difficult it was to prevent water from getting into them. The filling described by Mr. Preece seemed to be calculated to keep out water altogether. He quite agreed that many hard bitumen-cables became brittle occasionally.

Mr. Alfred J. Tonge said that a three-core cable, 1,320 feet long, had been suspended at the Hulton colliery. He asked whether Mr. Preece had made any tests for oxidation, or for the effect that atmosphere or temperature had upon the bitumen. In his own experience, nothing surpassed a coat of rubber for

the repeated taking-up and laying-down conditions that often prevailed in mines. This cable had been designed to meet the difficulty of moisture; but, unless the bitumen was free from cracks, there would still be trouble. Mr. Preece had spent a large amount of time in considering this matter, and it seemed reasonable that the members should give encouragement to engineers who were trying to overcome the difficulties specially attached to the use of electricity in mines.

Mr. Preece, replying to the discussion, said that, where a large amount of power was taken down the pit, it certainly might in some instances be better to take three single cables for convenience in handling; it must be remembered, however, that for electrical reasons this method was not so good for three-phase working, especially when large conductors were being used. Further, the single cables would of necessity be unarmoured, and, therefore, must be protected, say, by wooden casing. Armouring on the wires would create a heavy induction-drop. Personally, he would prefer to build up the main cable in units of convenient size, where a large power had to be taken down the shaft; this system also allowed of the possibility, in case of a breakdown on one cable, of another taking its load temporarily. He confessed, however, that he had advocated the use of three single cables; that was, however, before this special solid three-core bitumen-cable had been brought out. The special solid strand-filling would not allow any moisture up the strand. There was no fear of any harm arising from the squeezing pressure exerted on the cable when under single suspension; and, in such cases, the special construction of the solid three-core bitumen-cable compared favourably with the ordinary three-core cable. The cores were well gripped and protected by the ribbed outer sheathing, which also ensured a uniform distribution of pressure; while in the ordinary type the pressure was exerted locally. The solid three-core bitumen-cable was not soft actually; it was soft in comparison with some very hard types of bitumen-cable, but it was tougher and more resilient, and the latter quality was most important. Further, the hard type of bitumen-cable was not reliable; it would not stand the oxidizing influences present in collieries anything like as well as the type of bitumen used in the solid three-core cable. In cases where great flexibility

was required and the cable had to be moved very often, there was nothing better than vulcanized indiarubber; and the resilient type of bitumen in the special cable was the nearest approach to it. Most cables in collieries, especially shaft-cables, were permanently fixed.

DISCUSSION OF MESSRS. W. N. ATKINSON AND A. M. HENSHAW'S PAPER ON "THE COURRIÈRES EXPLOSION."*

Mr. Joseph Dickinson said that it might appear ungracious not to acquiesce in the conclusion arrived at by such high authorities, and after evidently unwearied painstaking enquiry. It was astounding and not readily admissible that a blown-out shot, with only dust to help, should travel through many miles of workings in several different seams and kill 1,100 persons; and, at all events, a little honest criticism might help the consideration of the point.

There were thirteen shafts, varying in depth with workings connected underground; and the workings of four of these shafts were seriously affected: No. 2 pit, upcast; No. 3 pit, bratticed, part downcast and part upcast; No. 4 pit, upcast; and No. 11 pit, downcast. Loud noise with clouds of smoke and dust came to the surface at Nos. 3, 4, and 11 pits; a cage at No. 1 pit was thrown upwards towards the pulleys; there was no surface-damage at No. 2 pit; the landing-floor was damaged at No. 3 pit; and the covering was blown open at No. 4 pit. Whilst below-ground, at No. 11 pit, the 1,257 feet (383 metres) hooking-on place and surroundings were damaged; at No. 4 pit, something similar happened; at No. 3 pit the 919 and 1,070 feet (280 and 326 metres) entrances were affected, some stoppings shutting off a fire being near the 919 feet (280 metres) mouthing; and at No. 2 pit the flame ceased. It required careful study of the several plans outlining the workings in the respective seams to follow the course of the blast. The blown-out shot was in the Joséphine seam, at the face of the Lecœuvre heading, aired by pipes, and one of two headings, about 450 feet in length, driven from an upbrow or rise-working out of the north 1,070 feet (326

* *Trans. Inst. M. E.*, 1906, vol. xxxii., pages 439, 340 and 507; 1907, vol. xxxiii., pages 124, 303 and 326; and 1907, vol. xxxiv., page 151.

metres) winning from No. 3 pit. From this point, the blast radiated in various directions into various seams, including the north-west district, the No. 2 pit, in the south-east. Another part turned back at an acute angle, and then divided, some going to the north and some by the 1,070 feet (326 metres) tunnel to No. 3 pit, up which some went. The blast passed into the south 1,070 feet (326 metres) tunnel and entered the east and west workings, that going west, apparently re-invigorated with fresh gas, extended to Nos. 4 and 11 pits, north and south of which extensive damage was produced. Worked-out districts were not shown on the plans, but only main roadways, and some main air-currents by arrows with feathered tails, and some of the blasts by arrows without tails. The position of the fire in the Cécile goaf near No. 3 pit was shown, also of the seven stoppings shutting it off, the shut-off part including a large area of goaf. Fires in mines were usually dreaded, and suitable precautions taken until the enclosed area became too much fouled to be explosive. This fire, however, discovered in an airway in the goaf four days before the explosion, did not cause alarm; work elsewhere went on as usual; and the shutting-off was only just finished before the explosion occurred.

The writers of the paper did not meet with any fire-damp; but their investigations did not begin until long after the explosion, and it might reasonably be supposed that they could not enter many, if any, of the goaves.

Fire-damp had, on a few occasions, been previously found in some parts of the workings. Therefore, in endeavouring to solve the difficult problem, it should be borne in mind that it seemed probable from burst piping that some fire-damp was present in the Lecœuvre heading where the shot blew out. The heading above the Lecœuvre heading was not at work; it was found much shattered after the explosion, and might have been full of fire-damp. Taking this as the starting-point, flame would extend far away, and combined with concussion of air and any fire-damp in the numerous goaves, together with gas distilled from the shut-off fire, it seems more likely than the hypothesis of dust alone. From below No. 7 stopping also, an unfeathered arrow showed the blast coming out of this goaf; and on the rise near No. 3 pit, two stoppings were blown inwards towards the fire; the blast apparently raked through this goaf.

In his (Mr. Dickinson's) time, excluding explosions from shots alone, he had investigated between 350 and 400 fatal explosions, large and small, in some of which dust contributed, but fire-damp played the leading part; and, so far as memory served, not one was caused from dust alone. The greatest explosion was at the Oaks colliery, Barnsley, in 1866, when 361 lives were lost including 27 rescuers. This explosion followed the firing of a heavily-charged shot, in about the time that it would take to count two; but it was in a fiery mine with accumulations of gas, and found yielding about 550 cubic feet of gas per minute after the explosion. Dust had long been recognized as a factor in fire-damp explosions. A few explosions were recorded as having occurred in strong air-currents, especially in intake air newly compressed by descent into the mine, the starting-point being a shot. Caution was, therefore, requisite. Fire-damp seemed the leading cause, but dust was an accessory. The writers' suggestions in this respect were, therefore, commendable Dust should be removed, or watered so far as not to occasion more harm than it would remedy. Spraying with water might perhaps help in dispersing fire-damp, instead of the now discarded batting out with cap and jacket.

The PRESIDENT (Mr. Charles Pilkington) said that the details were exceedingly complicated in the case of the Courrières explosion, and it seemed to him that dust must have carried it on. He could hardly imagine the presence of a body of gas large enough to blow up and down the staple pits and cause the havoc that had been wrought in so great a length of roadway. He thought that most explosions began with gas, but were extended by dust. At the same time, Mr. Dickinson had had so large and varied an experience of mine-explosions, that he deferred to his opinion, although he could not help thinking that the Courrières explosion was carried on by dust. He hoped that the dust question would be set at rest by the trials about to be made by the Government.

Mr. G. B. HARRISON (H.M. Inspector of Mines) could not fully accept Mr. Dickinson's view, that gas was the predominant factor and dust a possible accessory in all explosions. In many explosions, unless all the engineers who had investigated them were wrong as to the point of origin, the circumstances did not

favour Mr. Dickinson's theory. He (Mr. Harrison) instanced in particular the circumstances under which the explosions took place at Brancepeth and Wingate Grange collieries. It seemed to him that at the Courrières colliery dust must have been the cause of the explosion travelling over such long distances, and irrespective of the cause and the point of origin dust and air must have been the factors that carried on the explosion.

Mr. W. OLLERENSHAW wrote that, some fifteen or more years ago, he had an opportunity of making investigations after an explosion which occurred at the Ashton Moss colliery by which two men lost their lives and several others were injured. There were many points in connection with his investigations which were supported by Mr. Atkinson's and Mr. Henshaw's observations at the Courrières collieries. (1) No gas had been found at the point at which the explosion took place previous to the explosion, nor was any found at that point at any time after the explosion; (2) the point at which the explosion occurred was very dry and dusty; and (3) the flames from the firing of the coal-dust, in both directions in which they travelled, on coming to points at which the nature of the dust changed, or where the dust was moistened by water, were arrested as they were at the Courrières collieries. The explosion at the Ashton Moss colliery was proved to have been caused by a blown-out shot, fired at the junction of the main return-airway. The roadway in which the shot was fired was small, and, as a result of the increased velocity of the air passing the full tubs of coal, considerable quantities of dust were blown off the tubs and accumulated along the roadway; and, so far as this dust extended in both directions, the flames from the explosion had travelled, until arrested at wet points, caused by water coming from the roof. The airway, below the point at which the shot was fired and from which direction the air was travelling, was made through gob or waste; but no coal-dust was present in the airway, nor could any traces of the explosion be found in the airway. The fact that some coal-dusts were explosive pointed out the necessity of the experimental gallery suggested by Mr. Henry Hall, Mr. John Gerrard, and others; but in other mines the dust was not of so highly an inflammable nature as to be explosive. If samples of dust, taken from the roadways of any mine, were found (on being subjected

to a reasonable test in the experimental gallery) to be of such a nature that danger of a coal-dust explosion might be feared; then, H.M. Inspector of Mines might reasonably demand that remedial measures should be adopted in that particular mine, but it would be unfair to place all mines on the same footing. The dust in some mines, the result of floor-crushings, etc., and not of broken coal, was perfectly safe. He (Mr. Ollerenshaw) suggested two methods which would lessen if they did not altogether prevent the occurrence of coal-dust explosions: (1) the tubs used for carrying the coal from the coal-face to the surface should be kept in first-class repair, in order to prevent the leakage of coal-dust on to the roadways; and (2) the haulage-roads should be kept sufficiently large to prevent the air from travelling at such a high velocity as to blow dust out of the tubs whilst in transit to the shaft.

He thought that the members would agree that, if Great Britain was to maintain her supremacy as a manufacturing nation, the manufacturer should be supplied with cheap fuel. This fact ought not to be lost sight of in discussing what precautions should be taken to minimize the dangers from coal-dust; and, whilst taking steps to protect the lives of the workmen, care should be taken not to cripple the coal-industry.

Mr. Joseph Dickinson said that he had investigated the explosion that took place at Ashton Moss colliery. Return air, from the deep workings of the mine, was coming through a very small hole and blowing with great pressure into an upper level, and some men fired a shot into the compressed air, which, no doubt, was contaminated with fire-damp.

The President (Mr. Charles Pilkington) said that the composition of dust, its fineness as well as its quality must be considered. Coarse granular dust would not explode, but a very fine one would. Samples taken from the Clifton and Kersley pits had been tested, and the result confirmed this opinion. He had found also that, while floor-dust was comparatively harmless, the dust taken from the sides and roof was more or less explosive. Consequently, in watering any mine it was absolutely useless to water the bottom-dust unless the top and sides were also watered or cleaned. At the same time, he considered that the question of watering was fraught with great danger. Watering was bene-

ficial if it could be done without destroying the roof or lifting the floor; but, in every case where the floor was soft or the roof tender, more men might be killed by watering than would be saved by keeping them from the risk of an explosion.

Mr. Joseph Dickinson said that there were different kinds of blown-out shots. Holes drilled with an obstruction in the drilling had the effect of giving a twirl to the shot, in the same manner as a rifled barrel did to a bullet or bolt. He did not think that any drill-hole which was not bored straight should be allowed to be charged; it was dangerous to fire the shot in a drill-hole that was askew, as the flames spread out so widely.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,

HELD AT VICTORIA UNIVERSITY, MANCHESTER, JUNE 28TH, 1907.

MR. JONATHAN BARNES IN THE CHAIR.

Prof. W. BOYD DAWKINS conducted the members through the Geological Museum, and indicated some of the recent additions, including the skeleton of a Plesiosaurus, presented by Mr. W. H. Sutcliffe, and a large slab showing footprints of an enormous reptile found in the Wirral district and presented by Mr. W. Balfour Stewart.

Prof. W. BOYD DAWKINS read the following "Introductory Remarks on the Coal-measures":—

INTRODUCTORY REMARKS ON THE COAL-MEASURES.

By Prof. W. BOYD DAWKINS, D.Sc., F.R.S., F.G.S.

When the members considered Carboniferous forests, the vegetation covering the land, he thought that they ought to deal with the question of Carboniferous geography. Of course, as was well known, the vegetation followed a zone, more or less definite according to its relation to the sea-level. When they realized the reason why the seams of coal were so remarkably parallel to one another, they grasped the fact that they were vegetable accumulations growing on great tracts of flat land, close to water-level. They must discard the idea of isolated basins, as now represented by the coal-fields. The general idea, presented by Sir John Prestwich and Mr. A. R. C. Godwin-Austen as to the geography of this country in remote ages, was as follows:— A mountainous region in the Highlands of the north, a great tract near sea-level, extending over the lowlands of Scotland, round the Lake District, round North Wales as far south as Brittany, and extending over nearly the whole of Ireland with the exception of the Wicklow mountains, and to the east into the valley of the Rhine. This great mass of alluvium covered an area more than a thousand miles long and 500 miles broad. The forests, represented by coal-seams, grew on great tracts of flat land near the water-level. In some of the shales and sandstones, there are also remains of driftwood (*Dadoxylon*) carried down from the uplands by floods, and belonging to a flora which grew at a higher level. The character of the water was shown in some cases by shells: marine shells indicated the presence of sea-water, and fresh-water shells, fresh water. The question of the zones for the purposes of classification was now under discussion.

At the close of the Coal-measure period, this great mass of alluvium, no less than 7,200 feet thick in Lancashire, was thrown into a series of folds, and riddled with faults. In later

geological times, it was largely destroyed by processes of denudation, and the existing coal-fields are merely those portions of it which had been preserved, by being sunk deep beneath the then surface of the land, and by the protection offered by newer rocks.

Mr. David M. S. Watson read the following paper on "The Formation of Coal-balls in the Coal-measures": —

THE FORMATION OF COAL-BALLS IN THE COAL-MEASURES.

By DAVID M. S. WATSON, B.Sc.

The Upper-foot Mine of Lancashire and the Halifax Hard Bed in Yorkshire have been known for many years to contain in the actual seam of coal numerous calcareous nodules, enclosing beautifully-preserved plants. It has been found by Miss M. C. Stopes and the author that coal-balls occur in at least two other coal-seams in Lancashire: (*a*) one of these, well exposed in the banks of the river Tame at Stalybridge, is about 100 feet below the Woodhead Mill rock, and about 20 feet above the top of the Millstone Grit. (*b*) The other, worked about 100 years ago in a pit near Laneshaw Bridge, about 2 miles north-east of Colne, is in the Millstone Grit, probably in the second grit. Exactly similar coal-balls occur on the Continent at Orlau, in Silesia, and in Westphalia, in each case at more than one horizon. In all these occurrences the coal-balls are associated with marine conditions in the roof.

The roof is always a black or dark-grey shale, containing abundant crushed goniatites and *Aviculopecten*. In these shales also occur spheroidal concretions, containing the same fossils uncrushed. These are known as *baum-pots* and yield fine specimens of the contained fossils. Baum-pots have roughly the same composition as coal-balls: differing only in having a higher percentage of clay. The similarity in composition between baum-pots and coal-balls, both being impure dolomites, when taken in connection with the constant occurrence of baum-pots over coal-seams containing coal-balls, suggests some relationship between the two.

The conditions at the junction of the Upper-foot and Gannister coals to form the Mountain Four-foot seam, as seen at the Old Meadows pit, Bacup, renders this relationship almost certain. It is found, on approaching the junction of the Gannister Mine, that isolated coal-balls occur when there is a parting 10 inches

thick, between the top of the Gannister seam, which elsewhere is free from coal-balls, and the Upper-foot Mine with its marine roof. When the junction is reached and the parting is only 1 inch thick, numerous large coal-balls are found in the lower part of the Union seam, which represents the Gannister coal. It is found, in certain cases, that stems run through two or more coal-balls, thus showing that the latter cannot have moved since their formation. The often very irregular form of the coal-balls also testifies to the same fact.

It is consequently certain that the coal-balls must have some connection with the conditions prevailing during the deposition of the roof, and the explanation adopted by Miss Stopes and the present author is as follows:—It has been shown by Mr. H. B. Stocks* that the bacteria which produce decay are capable of reducing calcium-sulphate to the carbonate, which, being less soluable, is deposited. It seems almost certain that the same reaction would occur with magnesium-sulphate. Now, sea-water contains appreciable quantities of the sulphates of calcium and magnesium. It has been shown above that the marine conditions of the roof have something to do with the formation of coal-balls, and this occurrence of calcium and magnesium-sulphate in sea-water suggests that the necessity for the marine roof was to supply the raw material of the coal-balls. Another use of the sea-water was as a preservative. It has been found by Miss Stopes and the author that plants are perfectly preserved for a long time by a mixture of sea-water and peat.

Full information about the occurrence and probable methods of formation of coal-balls and some similar structures, notably the dolomite replacing coal at the Wirral colliery, described by Mr. A. Strahan,† will be found in a paper by Miss M. C. Stopes and the writer.‡ A short preliminary account has been published by Miss Stopes.§

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* "On the Origin of Certain Concretions in the Lower Coal-measures," by Mr. Herbert Birtwhistle Stocks, *The Quarterly Journal of the Geological Society of London*, 1902, vol. lviii., page 46.

† "On the Passage of a Seam of Coal into a Seam of Dolomite," by Mr. Aubrey Strahan, *Ibid.*, 1901, vol. lvii., page 297.

‡ "On the Present Distribution and Origin of the Calcareous Structure known as Coal-balls," by Miss M. C. Stopes and Mr. D. M. S. Watson.

§ "On the Coal-balls found in Coal-seams," by Miss M. C. Stopes, *Report of the Seventy-sixth Meeting of the British Association for the Advancement of Science*, York, August, 1906, page 747.

The CHAIRMAN (Mr. J. Barnes) said that Mr. Watson's paper had been interesting to him, as he had had some share in working out the composition of coal-balls; and he agreed with Mr. Watson's idea as to their being of marine origin, because dolomite was not altogether a marine body, although largely so. The question of dolomitization was not yet definitely settled, but he hoped soon to place something on record that would make the matter as simple as it was now difficult.

Mr. BERNARD HOBSON, in moving a vote of thanks to Mr. Watson, said that he had been specially interested in the relationship that Mr. Watson had pointed out between the coal-seam in the Wirral peninsula and the coal-balls in the coal. In the case of the Dolomite-mountains of the Tyrol, the deposit apparently had no connection with coal-seams. The question of the formation of dolomite was one on which there was great difference of opinion, and every observation which tended to show how dolomite might be formed under certain conditions would, he thought, probably lead to throwing light on its possible mode of formation in other cases. He thought that there was an instance of a dolomite-deposit cementing the pebbles in the river Neckar, at Cannstadt, Germany.* There were various ways in which dolomite could be formed, but the mode, in the case of coal-balls, was of special interest.

Mr. SYDNEY A. SMITH seconded the resolution, which was passed.

Mr. GEORGE HICKLING read the following paper on "Carboniferous Flora as an Aid in Stratigraphical Classification":—

* *Die Paragenesis der Mineralien*, by Prof. August Breithaupt, 1849, page 46.

CARBONIFEROUS FLORA AS AN AID IN STRATIGRAPHICAL CLASSIFICATION.

By GEORGE HICKLING.

The main object of the writer is to endeavour to show that fossil plants are more worthy of the attention of geologists, as an aid to the correlation of strata, than has of late been generally admitted.

For a clear discussion of any question of this kind it is essential that one or two fundamental geological terms should be used with greater precision than is commonly the case. "Formation," "system," and "zone" are such familiar terms, that their precise meaning and relation are apt to be neglected. They differ not merely in magnitude, but in kind. Formation was originally used, and should still be used, simply to denote a mass of rocks of a definite character, which might be traced as a sheet over a greater or smaller tract of country: it represents a particular type of sedimentation. System is defined in a totally distinct manner, although this is not always clearly recognized. While formations for the most part followed one another in unbroken succession, widespread unconformities here and there interrupt the sequence and split the whole series of stratified rocks into larger subdivisions or systems. A prevalent misconception must be corrected here: namely, that a system is a series of deposits defined by a particular assemblage of organic remains. It was perfectly natural that this idea should have been grafted on to the definition of a system in the days of cataclysmic theories; but, in view of the modern belief in the continuity and gradual modification of the organic world throughout geological time, it must be at once recognized that systems can only be defined by natural breaks in the succession of the rocks. A zone, on the other hand, is only palæontological in its conception. Interruptions in the series of deposits which make systems impossible, are the greatest hindrance to the zoning of the geological scale. Single species or groups of organisms may be used to define

zones, as at all periods there are species and groups which attain the height of their development. They are the dominant species of the time, and their abundant remains in a stratum mark it as having been formed at that time. Zones, then, but certainly not systems, are defined by certain dominant groups of organic remains.

The value of plant-remains for the definition of zones within a given system depends upon the amount of evolution which the plants or certain groups of them, have undergone while the rocks of that system were being deposited; that is, the extent of the changes in the dominant species. The first enquiry, then, must be: what are the chief groups of plant-bearing strata that must be included in the Carboniferous system, and what, approximately, is their relative position? A discussion of the intricate problems of the correlation of the Carboniferous rocks of Great Britain would be beyond the limits of this brief communication, and the outline-scheme set forth in plate iv. summarizes the most probable views, he believed, on this subject. The only points in this scheme likely to meet with serious opposition are the inclusion of Upper Old Red deposits in the Carboniferous system, and the position assigned to the Devonshire rocks. These, the writer hopes, shortly, to make the subject of a detailed paper. Meanwhile, he might remark that, following the definition of the system given above, the Upper Old Red must be included, while he believes that this is further necessitated by the contemporaneity of some, at least, of those deposits with part of the Carboniferous Limestone Series. Below that group of deposits there is a great unconformity, which will probably be found eventually to extend over the whole of the British Isles, and may also be traced on the Continent.

Taking this great break as a natural base, the Carboniferous system presents three well-known floras, which may very well indicate the amount of change undergone by plants during the whole of that period. Near the true base are found the plant-beds of Kiltorcan, Kilkenny; about the middle are the cement-stones and oil-shales of the Calciferous Series; and at the top are the various Coal-measure horizons.

Of the distinctness of these three floras it is unnecessary to speak at length. Kiltorcan has unfortunately yielded as yet only about ten species, or perhaps less; nevertheless, poor as the

flora is, it is perfectly distinct from that of the Calciferous Sandstone or Cement-stone, although presenting some affinity with it. Luckily, the knowledge of the plants of this period may be extended from the rich beds of Bear Island, the plant remains from which have been described by Heer, and more recently by Prof. A. G. Nathorst.* *Archæopteris* is there represented by three species, *Bothrodendron* by five, and the peculiar *Sphenopteridium* has likewise five species. These three genera may be regarded as the characteristic forms of the Upper Old Red flora. They are represented in the Calciferous Series, but by almost completely distinct species. *Bothrodendron* and *Archæopteris* only are scantily represented, even as genera, in the Coal-measures. The total absence of many of the commonest upper Carboniferous forms, *Sigillaria*, *Alethopteris*, *Neuropteris*, and *Pecopteris*, is no less striking a feature of this earliest flora. So far as one can at present judge, the Calciferous-Sandstone flora occupies a fairly intermediate position between that of the Upper Old Red of Ireland and Bear Island and that of the Upper Carboniferous. It bears a very similar relation to both. Most of the important Upper Carboniferous genera appear in the Calciferous Series, but they are represented mainly by distinct species, while there are several genera peculiar to each group. Of genera peculiar to the Calciferous Series, *Sphenopteridium*, *Rhacopteris*, and *Adiantoides* may be mentioned, while the complete or almost complete absence of the genera *Pecopteris*, *Alethopteris*, and *Neuropteris* is still noteworthy, although these begin to appear in slightly higher beds. Thus, the wide distinction between the floras and the great divisions of the Carboniferous is abundantly evident.

The only doubt that could be cast on the value of these distinctions would be on the possibility of their being due to mere local conditions, and not to the evolution of the plant-world. If corresponding plants can be shown to exist at similar horizons in a number of localities, this objection will be overruled. Evidence on this point is steadily accumulating, and it is pointing in the right direction. Telia Quarry, near Prestatyn, contains a plant-bed, referred by Mr. R. Kidston, from its plants, to the Calciferous Series, and by Dr. Wheelton Hind, from its mollusca, to the Pendleside series. Formerly, these two horizons were considered as most widely separated; but, as indicated in the diagram (plate

* *Zur Oberdevonischen Flora der Bären-insel.*

iv.), the writer thinks that the evidence now points to their being comparatively near. Similar plants are associated with similar shells in the Limestone Series at Poolvash, near Castleton, Isle of Man. In the diagram (plate iv.), again, the writer has placed the Culm Series of Devonshire as entirely Upper Carboniferous, and this for purely stratigraphical reasons. From an examination of the plant remains, Mr. E. A. Newell Arber* had concluded that most of the Middle and Upper Culm of Mr. W. A. E. Ussher, is of Middle Coal-measure age. Instances of this kind to illustrate the reliability of plants for determining horizons, when they occur under somewhat abnormal conditions, might be considerably multiplied; but that scarcely seems necessary.

The possibility of using plant-remains for the determination of horizons in a broad way would probably be admitted by most geologists with little demur. It is more especially with regard to their applicability to finer zoning in Coal-measure deposits that scepticism seems to prevail. It is the more unfortunate that this should be the case, as work in this field is of the highest possible value both scientifically and economically; while at present the number of workers is minute. This hesitation to accept results based on plant-remains, may, the writer thinks, be traced to one of the very circumstances which appeared to him to make these fossils particularly suitable for the purpose. Certain genera (*Neuropteris* is a good example) have been divided into large numbers of species, which can only be separated with great care. Geologists as a rule have little botanical knowledge, and identifications of species of these genera have been more often wrong than right. Whether results can be trusted when identifications are so difficult is the natural query. The difficulty in these cases is due to the fact that species *do* run into one another. The evolution of a whole genus is in full swing, and each main form is producing numerous varieties. How many species may be recognized is a matter of small importance; the essential fact is that the great number of varieties points to their rapid production, and, it may be assumed, to their equally rapid extinction. The conditions are exactly paralleled among the genera of corals and brachiopods which have been used in zoning the Carbon-

* "The Fossil Flora of the Culm-measures of North-west Devon, and the Palæobotanical Evidence with Regard to the Age of the Beds," by Mr. E. A. Newell Arber, *Philosophical Transactions of the Royal Society of London*, 1902, vol. cxcvii., series B, page 291.

iferous Limestone or the ammonites of the Mesozoic rocks, in which it has been found convenient to retain only the main species, and to group the others round them as variants.

Considerable success has already attended the patient and careful work of Mr. R. Kidston, who has been able to show that marked distinctions exist between Lower, Middle, and Upper Coal-measure floras; so marked, indeed, that each has numerous species peculiar to itself, while the common species of one division are rarely common in either of the others, making the actual floras in the field look much more distinct than might appear from lists. With careful collecting, there is little doubt that much finer subdivision and correlation of this important series of rocks will ultimately be possible, and the way will be paved to that accurate and detailed knowledge of their history which must ultimately enable us to predict their position and development in those regions where they now lie buried below later deposits. One great barrier stands in the way of the successful pursuit of this enquiry: the scarcity of specimens, the exact horizon and locality of which are known. In view of the enormous economic value of the results to be attained, though even a single fruitless sinking were saved, the writer feels that he cannot better conclude than with an appeal to the members to assist in supplying the necessary materials.

The Chairman (Mr. J. Barnes), in proposing a vote of thanks to Mr. Hickling for his paper, trusted that the members would give Mr. Hickling ample material, so that he could put this matter on a proper footing, just as Dr. Wheelton Hind and others had done in regard to the mollusca.

Mr. Bernard Hobson, in seconding the motion, expressed the opinion that in the end the results obtained from mollusca would be found to agree with the results obtained from plants; and, if they did not, it would seem to point to the fact that mistakes had been made in working out the results.

The motion was passed.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

ANNUAL GENERAL MEETING,

HELD AT THE UNIVERSITY COLLEGE, NOTTINGHAM, OCTOBER 5TH, 1907.

MR. W. G. PHILLIPS, RETIRING-PRESIDENT, IN THE CHAIR.

The SECRETARY announced the election of the following gentlemen:—

MEMBERS—

Mr. JOHN CHARLES BINKS, Bagworth, Leicester.
Mr. MICHAEL STACPOLE COXON, 16, Warwick Gardens, Kensington, London, W.
Mr. ROBERT HARRISON, Moorgreen Colliery, Newthorpe, Notts.
Mr. WILLIAM PATTISON, Wollaton Collieries, Nottingham.
Mr. JOSEPH HERBERT PHILLIPS, Ansley Hall, Atherstone.

ASSOCIATES—

Mr. SYDNEY GEORGE RIGDEN, Guilford Colliery, Whitfield, near Dover.
Mr. GEORGE B. TRISTRAM, Southfield Lane, Whitwell.

STUDENTS—

Mr. GERALD LANCASTER, Broom Hill, Woodthorpe, near Nottingham.
Mr. HENRY JAMESON MEIN, Tibshelf Collieries, near Alfreton.

ELECTION OF OFFICERS, 1907-1908.

The SCRUTINEERS, Messrs. C. W. Phillips and H. Shaw, reported the result of the ballot for the election of officers for the ensuing year, as follows:—

PRESIDENT:
Mr. G. J. BINNS.

VICE-PRESIDENTS:

Mr. G. H. ASHWIN.	Mr. W. HAY.	Mr. J. H. W. LAVERICK.
Mr. G. C. FOWLER.	Mr. W. H. HEPPLEWHITE.	Mr. B. McLAREN.

COUNCILLORS:

Mr. P. BEAUMONT.	Mr. H. R. HEWITT.	Mr. E. D. SPENCER.
Mr. J. T. BROWNE.	Mr. T. G. LEES.	Mr. G. SPENCER.
Mr. R. H. F. HEPPLEWHITE.	Mr. J. MEIN.	Mr. H. STEVENSON.
Mr. C. R. HEWITT.	Mr. H. E. MITTON.	Mr. J. T. TODD.

The Annual Report of the Council and Abstract of Accounts were presented as follows:—

THE MIDLAND COUNTIES

Dr. THE TREASURER IN ACCOUNT

	£ s. d.	£ s. d.
289 Members, as per list, 1906-1907		
18 *less*, Life members and members paid in advance		
271		
3 Members @ 15s.	2 5 0	
268		
1 Member, to pay balance	1 1 0	
267 Members at £1 11s. 6d.	420 10 6	
		423 16 6
6 Associate members, as per list		9 9 0
106 Associates and students		
3 *less*, paid in advance		
103 Associates and students at £1		103 0 0
4 Associates and students, transferred to members		4 8 0
11 New members and entrance-fees		28 17 6
1 New associate member		2 12 6
9 New associates and students		9 0 0
The Butterley Company		5 5 0
Subscriptions paid in advance:—		
Members	22 1 0	
New member and entrance-fee	2 12 6	
Associates and students	3 0 0	
Member paid portion	1 7 0	
		29 0 6
Arrear-subscriptions, as per list	103 14 6	
Less, portion previously paid	0 10 6	
		103 4 0
		£718 13 0

INSTITUTION OF ENGINEERS.
WITH SUBSCRIPTIONS, 1906-1907. **Cr.**

	Paid. £ s. d.	Unpaid. £ s. d.	Struck off List. £ s. d.
208 Members at £1 11s. 6d.	327 12 0	......	......
37 Members, unpaid	......	58 5 6	......
21 Members, resigned, etc....	......	......	33 1 6
3 Members, at 15s....	1 10 0	0 15 0	......
1 Member, paid portion	0 5 6	1 6 0	......
1 Member, paid balance	1 1 0	......	......
271			
2 Associate members, paid	3 3 0	......	......
3 Associate members, unpaid	......	4 14 6	......
1 Associate member, resigned	......	......	1 11 6
6			
70 Associates and students, paid	70 0 0	......	......
12 Associates and students, unpaid ...	......	12 0 0	......
14 Associates and students, struck off ...	......	......	14 0 0
3 Associates and students, resigned ...	......	......	3 0 0
4 Associates and students transferred ...	3 0 0	1 0 0	......
103			
4 Associates and students, difference as members, and entrance-fees	3 6 0	1 2 0	......
11 New members and entrance-fees ...	28 17 6	......	......
1 New associate member	2 12 6	......	......
9 New associates and students	9 0 0	......	......
The Butterley Company	5 5 0	......	......
Subscriptions paid in advance	29 0 6	......	......
	484 13 0	79 3 0	51 13 0
Arrear-subscriptions, 1905-1906	31 13 6	22 6 6	49 4 0
	516 6 6	101 9 6	100 17 0
			101 9 6
			516 6 6

Audited and found correct,

JOHNSON PEARSON
JOHN HOLBROOK } AUDITORS.

August 23rd, 1907.

£718 13 0

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS: ABSTRACT OF ACCOUNTS FOR THE YEAR ENDING JULY 31ST, 1907.

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance in bank				211	2	5
208 Members paid at £1 11s. 6d.	327	12	0			
1 Member paid balance	1	1	0			
1 Member paid portion	0	5	6			
3 Students transferred	4	14	6			
				333	13	0
2 Associate members				3	3	0
70 Associates and students				70	0	0
11 New members and entrance-fees				28	17	6
1 New associate member and entrance-fee				2	12	6
9 New associates and students				9	0	0
The Butterley Company				5	5	0
Transfer-fees				1	11	6
2 Members at 15s.				1	10	0
Subscriptions paid in advance				29	0	6
Sales of *Transactions*				2	0	9
Repaid by Messrs. Andrew Reid & Co., Ltd.				3	17	6
Midland Railway debenture interest				15	4	0
Arrear-subscriptions paid				31	13	6
Bank interest				1	8	9
Interest on deposit account				6	2	9
				£756	2	8

PAYMENTS.

	£	s.	d.	£	s.	d.
The Institution of Mining Engineers:—						
Call 1906-1907:—Vols. xxxii. and xxxiii.	318	5	0			
,, 1905-1906:—Vols. xxx. and xxxi.	13	6	0			
Transactions sent to Members paying arrears	12	0	0			
				343	11	0
Exchanges and excerpts				6	10	5
Printing and stationery				31	4	3
Auditors				1	11	6
Reporting proceedings				7	1	5
Postages, parcels, etc.				20	14	7
Travelling and incidental expenses				10	12	4
Expenses of meetings				4	6	6
Rent of room for storage of *Transactions*				2	10	0
Secretary's salary, use of office, etc.				100	0	0
Fire insurance				0	3	6
Miscellaneous expenses				1	5	7
Bank commission				0	14	0
Cheque book				0	2	6
Balance:—						
Deposit account	204	8	9			
Interest on deposit account	6	2	9			
Current account	15	3	7			
				225	15	1
				£756	2	8

Audited and found correct,

JOHNSON PEARSON }
JOHN HOLBROOK } AUDITORS.

August 23rd, 1907.

ANNUAL REPORT OF THE COUNCIL, 1906-1907.

The usual statistics as to membership and finance are herewith presented by the Council:—

	Year 1904-1905.	Year 1905-1906.	Year 1906-1907.
Honorary members ...	16	16	16
Life members ...	6	6	6
Members ...	283	283	278
Associate members ...	4	6	6
Associates ...	59	64	58
Students ...	39	42	38
Totals ...	407	417	402

	£ s. d.	£ s. d.	£ s. d.
Cash receipts ...	567 14 6	573 7 11	545 0 3
Cash payments ...	546 3 0	563 10 11	530 7 7
Bank-balance ...	201 5 5	211 2 5	225 15 1
Invested funds ...	640 0 0	640 0 0	640 0 0
Totals ...	£841 5 5	£851 2 5	£865 15 1

The following table shows the alteration in membership during the past twelve months, an unusually large number of members having being taken off the list by reason of the non-payment of subscriptions:—

	1905-1906.	Less: Dead.	Less: Resigned.	Less: Transferred.	Add: Elected.	Add: Transferred.	1906-1907.
Honorary members	16	—	—	—	—	—	16
Life members ...	6	—	—	—	—	—	6
Members ...	283	2	18	—	11	4	278
Associate members	6	—	1	—	1	—	6
Associates ...	64	—	9	1	4	-	58
Students ...	42	—	8	3	7	—	38
Totals ...	417						402

The meetings have been numerous and well attended, and the attention of members may be drawn to the fact that they have the right of joining any meetings called by the Midland Institute of Mining, Civil and Mechanical Engineers, whose headquarters are in Sheffield, in addition to those immediately connected with this Institution and The Institution of Mining Engineers.

The issue of the *Transactions* has been considerably improved, as foreshadowed in the annual report of last year.

The thanks of the members and of the Council are due to the colliery companies and other firms in Leicestershire who kindly entertained the members in May last, and have been forwarded officially to those companies.

The Council would be glad to receive notice of papers for reading and discussion. The number of papers brought forward by members for reading at the meetings has been by no means satisfactory. With the object of stimulating the production of such papers, the Retiring-President, Mr. W. G. Phillips, has offered the sum of £5 to be given in prizes to the writers of those papers which the Council may consider deserving of recognition. It is confidently hoped that members will take advantage of this opportunity.

Mr. HENRY DAVIS (Derby), in moving the adoption of the report and balance-sheet, remarked that he had much pleasure in doing so on account of their excellent and satisfactory character. He understood that of the amount at the bank, a further £200 had been, or was about to be, added to their investments. He would like to draw especial attention to the paucity in the number of papers, and he desired to impress upon the members the desirability of writing papers, so as to maintain and stimulate the interest in the Institution. The thanks of the members were especially due to their Retiring-President for his generosity, which might help towards securing papers, especially from the younger members.

Mr. W. WALKER (Nottingham) seconded the motion, which was unanimously adopted.

Mr. G. J. BINNS (Duffield), in taking the presidential chair, said that his first duty was to move a vote of thanks to the Retiring-President. Mr. Phillips came from a district which was not in the centre of their engineering area, but he brought into that area an energy, a tactfulness, and a *bonhomie* which could not be excelled.

Mr. J. T. TODD (Blackwell), in seconding the resolution, said that every member would recognize the ability which Mr.

Phillips had displayed during his term of office as their President. For two years he had guided the Institution, his criticisms had been kindly, and his advice had been of the greatest value to them. They knew, too, that after he had laid down the presidency, he would continue to take as keen an interest in its welfare as he had done during the time that he was in office. It would be the wish of all of them that at no distant date Mr. Phillips might occupy the higher position of President of The Institution of Mining Engineers.

The resolution was cordially adopted.

Mr. W. G. Phillips (Atherstone) said that he was keenly alive to the heartiness with which they had accorded their thanks. The position was largely one of honour, for they had such an excellent secretary that he relieved the President of a large share of the work. He hoped that the Institution would continue to flourish, and he could assure them that his own interest, which had been quickened during the past two years, would continue undiminished.

The President (Mr. George J. Binns) then delivered the following "Presidential Address":—

PRESIDENTIAL ADDRESS.

By GEORGE J. BINNS, F.G.S.

In the first place, it is at once a duty and a pleasure to express to the Council of this Institution, and to the members generally, my deep sense of the compliment paid me in permitting me to occupy for a year the presidential chair, a position to which every member should aspire, and one which, I hope, may in future years be filled by many of those whom I have the honour to address. At the same time, I would express a hope that, during my term of office, the Institution may pursue that course of usefulness and instruction which it has followed for so long.

It is customary for the incoming President to devote a little time to a consideration of some more recent advances in mining science; to detail, from the presumably lengthy period over which his memory stretches, some of the changes that have taken place; to point out to the younger members of the Institution what rocks to avoid, and what pitfalls may await them during their arduous career. For many and obvious reasons, it is not open to me to adopt any of these well-worn paths. During some years my way in life, though near to, has not run upon the conventional engineering track; and, with your kind indulgence, I shall ask you to stray with me a little from the beaten path, and look upon the profession to which we belong from a standpoint perhaps somewhat outside the common round.

Even as a landscape or a picture, however well known to us, may become endowed with new beauties by being looked at from different points of view, so may our daily occupation assume a diverse and not unpleasant aspect, if we regard it in a light which is unfamiliar. Will you therefore lay aside, for the few minutes during which I shall detain you, the thought of the daily duties which no doubt occupy so much of your care, cast aside the question of cost and selling price, and the Miners' Eight Hours Bill, and bear with me while I ask you to consider the position of the mining engineer, not so much as the simple producer of

so much coal at so small or so large a cost, not as a machine for grinding out dividends when trade is good and bearing blame when trade is bad, but as a member of a great army, fighting day by day, and often night by night, with the gigantic forces of nature. At this point you will see the necessity which is forced upon me of defending myself against an inevitable accusation of plagiarism, and that so gross and barefaced as absolutely to invite detection.

At a meeting held only the other day, in a neighbouring town, the President of the National Association of Colliery Managers cut—so to speak—the ground from under my feet, by dealing with the position of the colliery manager from the same point of view, and not only so, but by treating the subject with a rhetorical skill to which I cannot hope to aspire. The obvious course was for me to choose another subject, and leave Mr. Houfton in undisputed possession of the field, but there were several objections, not the least being perhaps the necessity of choosing, at the eleventh hour, when my notes were already practically written, a new theme. Fortunately, should my bare word fail to convince you, there is in my hand a letter dated a little more than fifteen years ago, from my old friend, Prof. A. S. Herschel, who has so recently joined the great majority, and whose former honourable connection with this Institution—even though so many years ago— makes it appropriate for me to express the great regret felt, not only by myself, but by all who respected his vast scientific attainments, and more especially by those who knew his kindly and simple disposition, his entire freedom from self-seeking and self-advertizing pushfulness, and that absolute devotion to science which one might have expected from one of his honoured name. My idea at that time—and it has already been in my mind for some four or five years—was a paper on "The Influence exerted by the Various Forces of Nature on the Operations of Mining," but Prof. Herschel did not favour the idea, and in a very long letter proposed an alteration in the title to "Various Measurable Forces." He entered in some detail into chemical and mechanical force, urging that what he called "Mammon views and promptings" should not intrude into what ought to be a purely philosophical consideration, bounded on all sides by the rigid lines of strict scientific knowledge, and steering very clear of "lucrative values." He con-

tinued—if you will pardon my quoting so much—"but very contrary capabilities of the same energy-descriptions (disaster—instead of gainful ones) under varying conditions of its uses, may be known to the reader, which would lead him to say that lack of preciseness in specifying the conditions of operation with some such 'force' in question, had, in the natural course of the writer's inclinations towards gain and profit from Nature's assistance, led him into (perhaps quite unintentionally) giving evil counsels." I cannot, alas! obtain permission to make public use of what was merely a private letter, but must assume that leave, and apologize to you, so few of whom knew him, if admiration for my old friend and teacher's character and attainments has given in my mind greater interest to his words than others can feel.

Now that I have proved, I hope to your satisfaction, that in apparently following Mr. Houfton's lead I am merely resuming a path which was already trodden some twenty years ago, it may be explained that my original intention was to deal with the subject, if not quite so seriously as would have pleased Prof. Herschel (for my inadequate knowledge would have, in any case, prevented that), yet to catalogue the various natural forces, and opposite each to make a schedule of the mining operations effected; something after the manner of a list of permitted explosives or industrial diseases. After, however, enquiring from some of my learned friends, it seemed impossible to obtain a list which was not open to serious objections, and as to-day I speak, as it may be said, in freedom from open criticism, I abandoned the idea of making an orderly paper, and assumed your consent to wander awhile in dwelling on a subject which has always had, for me, a peculiar fascination.

Among the various forces of Nature, that which more than any other affects us in our daily operations is, I think, the attraction of gravitation: so familiar to us from our earliest childhood that its very existence escapes attention; so apparently simple and yet of such complexity that it is among one of the unsolved mysteries of science; so relentless in its course, so inevitable in its action; in its results so disastrous, and yet so necessary in its usefulness that without it the whole fabric of creation would cease to exist. Speculations as to what would result if this power were suddenly to cease are to my mind

impossible, as upon it depends the whole existence of animate and inanimate matter. If some poor miner comes to his end, crushed out of human likeness by the roof of his working-place, we say that the stone fell upon him; if a rope breaks and only mangled corpses reach the bottom of the shaft, our regretful explanation is that the cage fell. These phrases but baldly and imperfectly state the case. In each instance the force opposed by us to the attraction of gravitation proved insufficient to prevent its action, and the materials which we say fell were dragged down by a power which the scientist has taught us to calculate to a nicety. Of the fatalities which still so unfortunately accompany mining operations, how large a proportion is due to the fact that we have underestimated the power which is always threatening us! The Damocletian sword has proved too great a strain upon the suspending hair, and another victim is claimed by the insatiable earth. To combat successfully with gravity, we need to employ an equal or superior opposing force. We say that this thing weighs a ton, and we place beneath it four supports, each capable of resisting a pressure of five hundredweights. That is simple, but when it comes to dealing with the solid crust of the earth, which we propose to lower by several feet, how can we tell its weight? Then comes in the technical skill which we have made our own; and, in a way which ought to excite the admiration of the world, the mining engineer lays his plans, sets his timber, builds his packs, and lets down the solid crust of the globe, simply, safely, and without advertisement or fuss.

Compare this operation with the works of the civil engineer. He has unlimited cash, ample light and air, no cost per ton to work to, and the applause of the multitude to look for. Sometimes he bores beneath the surface of the earth, and becomes a miner: he drives what we should call a cross-measure drift through, for instance, a corner of the Jungfrau; true, it is high above the sea, the rock is hard and the climate cold. No timber or support is required, and you may travel for a mile or two, at a cost of 10 francs, in a little electric carriage, and peep through a bolt-hole at a dense fog. The guide-books speak of it as one of the greatest engineering achievements of modern times, but we know of hundreds of better roads, thousands of feet below the surface of this country, roads driven by men whose names

will not go down in history, but whose memories are no less deserving of a niche in the temple of fame than those of the civil engineer whose works are open to the light of day.

How many of the uninitiated, travelling through the coal-fields of Great Britain, and catching glimpses of a colliery as they rush by, are aware that below those headstocks are engineering works as wonderful as any Channel Tunnel and as deserving of applause as any Forth Bridge? Who gives credit for the daily fight against explosions of gas, against gob-fires, overlying water, the weight of thousands of feet of superincumbent strata, and the innumerable difficulties and hardships which are to us matters of daily use? The public pampers the collier, and considers nothing too good or too expensive for him. Does it ever show any desire to spoil with adulation or admiration the man who, while he has to work physically like a navvy, has ever to keep his intellect alert, his precautionary eye open, and who is—so far as I am aware—the only man in this country who is by law held guilty until he has proved his innocence?

While the attraction of gravitation is possibly of more constant importance to the engineer, it cannot be denied that the manifestations of chemical action are of no less striking interest to the student. At the same time, I do not propose to enter into any details of chemistry and chemico-physics as affecting the formation either of metalliferous veins and deposits or of seams of coal. Let it suffice that by the action of a far-seeing Intelligence there exist, stored up ready for the use of man, all those materials which are so necessary, not only for the carrying out of our engineering designs, but for the furtherance of trade and industry. Nor is it intended to mention, however hurriedly, the processes by which the assayer extracts from these ores their hidden wealth, or how the chemist from the unpromising materials which we provide in their rough form obtains the most alluring scents and essences and the most gorgeous colours.

It will be sufficient to glance in passing at two great manifestations of this force which must at once occur to our minds. The first and most striking is the disastrous chemical union which takes place when the correct proportions of explosive gas and atmospheric air are heated to a sufficiently high temperature to cause sudden combustion accompanied by enormous expansion. Then our best and most costly mining works are

but as straws before the wind; the safeguards in which we placed our trust prove but broken reeds; and another tale of lost lives and ruined property is added to the already lengthy and lamentable list. After the devastating blast comes yet another chemical action, and those who have escaped instant annihilation are face to face with the deadly after-damp, or the no less murderous oxidation of the timber and the coal-seam, which we call fire.

Less striking in its effect, but none the less a daily enemy of the miner, is the slow process resulting in what is known as spontaneous combustion, which, on account of the minor violence of its manifestations, holds a less conspicuous place in the public eye. Much has been written and published on this subject, but to this day the matter seems to me to be treated in a rule-of-thumb manner, and not to have received the scientific investigation which it undoubtedly deserves. Some authorities claim that the most bituminous coals are most prone to auto-ignition; but, on the other hand, it is a matter of common knowledge among those acquainted with that class of mining that the brown-coals and lignites which are so largely worked in other countries than this, and to which the term "bituminous" can by no stretch of the imagination be applied, are possibly more affected than any variety of fossil fuel. Even to this day the causes and treatment of underground fires are discussed and argued about without any valuable and definite result. Are they caused by pyrites in the coal, or are they not? Should we ventilate freely, or should we shut off the air? Ought water to be used, or should the place be kept dry? Is it wise to fill out, or to dam off? If we do dam off, are we, in using clay dams, exhibiting intense skill or the crassest ignorance? Can anyone give a conclusive and satisfactory answer to any of these questions? Each of us has his own view, and circumstances may no doubt influence the opinion that we hold; but, so far as I can see, the last thirty-five years has not very materially advanced our knowledge of a subject which is to some pits a daily menace.

Heat may be divided into the internal heat of the earth and the heat that we draw from the sun. If time allowed, I should like to have dwelt for a few moments on the recent discoveries of science, which have completely modified our ideas as to the internal heat of the earth, its dissipation into space, and the consequent abandonment of the old theories of physicists and geolo-

gists as to the duration of geological history and as to the period which may be expected to elapse before the earth that we inhabit will become a frigid and lifeless globe. But not only would such references be a little outside the present scope of my subject, they would also, I fear, trespass too hardly on your kind indulgence. To us the internal heat of the earth is of the deepest interest, for at some depth below the surface we are brought face to face with a barrier which, in the present state of our knowledge, we cannot pass. Human endurance is but small, and when the Plutonic forces say, "Thus far shalt thou go, and no farther," we must desist from our quest and look for some better weapons of war. And when we come to consider what has been done to remove this barrier, the answer is, practically nothing.

Depth we can overcome by increasing our lifting power, and when the diameter and length of our ropes become, for obvious reasons, incapable of extension, we can take refuge in multiple lifts; so that, so far as I can see, apart from the difficulty of dealing with the attraction of gravitation, which we call "weight," an indefinite distance from the surface might be attained. But the heat of the earth increases as we descend, and if we wish to reach any great depth we must discover some means of overcoming this obstacle. Till that day, we can rob Nature of her buried treasures for only a few thousand feet. Who will tell us of a cooling agent? Late researches in chemistry have revealed methods of producing, with comparative facility, low temperatures which a few years ago were undreamed of. Will the chemist supply us with a means of so reducing the heat of the earth, that we can continue our operations deeper and deeper towards the centre? Or by that time, will fuel, as we know it, have become obsolete? Radium, as is known no doubt to you all, will give off enough heat to raise in one hour its own weight of water from the freezing point to the boiling point. Shall we use it as a means of obtaining that heat which is so necessary? Or shall we have learned by that time how to draw from the stores of heat in the globe sufficient to stoke our boilers? To us, whose occupation is so much belowground, the heat of the sun would seem to be of but slight importance or interest, but in other countries, and amid other kinds of mining, heat and the absence of heat may determine the limits of possible work.

In very hot and very dry climates, where little or no water can be found, the operations of the miner are carried on with extreme difficulty, and in high and cold regions the face of nature is bound in an icy grasp, which prevents the exploitation of the mineral riches, except during, it may be, a very small proportion of the year.

The last force to which I shall refer is electricity, and I do so with considerable diffidence, for many, if not most of my audience, have so much greater familiarity with the subject than I can claim, that a not unnatural fear attacks me of inviting criticism and possible blame. At the same time, it is impossible to avoid notice of a natural force, the adaptation and utilization of which bid fair to revolutionize all known engineering methods and to change the face of the industrial world. And while gravitation and heat and chemical action are forces which pursue their silent opposition to us, electricity does not, so far as I am aware, thrust itself much upon our notice until we ask its aid. "Canst thou send lightnings that they may go and say unto thee, here we are," asked the afflicted Patriarch, and in these days we might reply that we can indeed harness the thunderbolts of Jove and turn to our uses the lightnings of Heaven. By means of this wonderful and unknown essence we can converse across continents, and convey the energy of our coal to distances undreamed of in the past. Looking back over the last quarter of a century, there is certainly no change in mining so striking as the introduction of electrical machinery, and not unnaturally one is led to speculate on the improvements which may take place in the future. Sir Hugh Bell, speaking as President of the Iron and Steel Institute, has predicted that before long the great Atlantic steamers will be propelled by electricity, wirelessly conducted from the Falls of Niagara. Can we look forward to having our secondary haulage, our distant pumping and coal-cutting carried out in a similar manner, by electricity generated on the surface, possibly at some central station, where the greatest economy in production can be maintained?

It may be that other natural forces exist which should be mentioned, and among them, no doubt, centrifugal force finds a place, but this is so continuously and, fortunately, so successfully opposed by the attraction of gravitation, that I need not

detain you by dwelling on it; nor need consideration of the force of cohesion, all-important though it is, occupy our time. Still it is worth spending a moment in considering the marvellous balance which exists between gravity, centrifugal force, and cohesion; and although speculation could lead to no definite result, it would be interesting to think what would happen were one of the two former to overcome the other, or were the force of cohesion to become inoperative. Suppose, for instance, that the earth were to revolve at seventeen times its present speed, there would be no inducement for bodies to maintain their position on the surface; and suppose, on the other hand, that the revolutions were so slow as to do away with centrifugal force, our powers of motion, and of removing articles from the ground, would be materially reduced.

And now I have to consider what measure of success has attended our efforts. To man was given dominion over the fishes of the sea, and over the fowls of the air, and over the cattle, and over all the earth. How has he availed himself of that great inheritance? Has he buried his talent in the earth, or has he striven with all the intellect that was his birthright to overcome the great natural adversaries which at the same time were called into being? And while I draw a line between man and Nature, and place him in opposition, so to speak, to his great Mother, I do not lose sight of the fact that of all Nature man is the crowning point and the coping-stone. The study of natural history must embrace all the earth, and the only differentiation possible to me is that of all creation to man alone is given power over the rest of his fellow-creatures and, to a certain and limited extent, over the inanimate world. Have we maintained that dominion which was our greatest gift, and which distinguishes us from the rest of living creatures? What has been the measure of our victory over the lightning, the volcano, and the earthquake? What are our outputs compared with the vomiting of Krakatoa and the outpourings from Skaptar Jökull; what avail our strongest structures against the tremblings of mother earth; and where are our precautions when the electricity of Heaven is let loose? In spite of our study and our civilization, in spite of the accumulated knowledge of centuries, we have to stand reverently on one side and acknowledge our impotence.

Quite recently I had the privilege of listening to an eloquent

address delivered by the late President of The Institution of Mining Engineers, in the course of which he dealt with the improvements observable in the history of mining during the last quarter of a century; and while the science of mining has no doubt made, during that period, enormous strides, it struck me that among the points to which Mr. Deacon called attention there was hardly one which could be called a discovery of any importance. Improvements in education, in safety of working, in mechanical engineering, in hauling and coal-cutting, in boilers and in coal-washing are all acknowledged, but to my mind it seemed that the underground conveyor was the only one worthy of the name of an actual discovery. Possibly I am wrong, but when we look at the history of the last quarter of a century in other branches of science, and note the discoveries, for instance, of new chemical elements of such astounding characteristics that they necessitate a new conception of the properties of matter and a new calculation of geologic time, of wireless telegraphy, and of other novelties in various branches of science, it seems to me about time for the mining engineer to startle the world by some striking development. Undoubtedly, during the recollection of those of us who are approaching the limit of our engineering life, there have been marvellous changes in the conditions and practices to be found at the coal-mines of this country; but while, in reference to radium, a recent writer has said, "we may well account it a supreme privilege that it has fallen to our lot to live in the days of this discovery," I cannot place my hand on any invention in mining engineering, during my experience of over a third of a century, which stands out in a similarly striking manner.

Still each of us has, I trust, done his best, and if we pause to ask ourselves what we have done as a profession among the countless millions of workers who have striven since Tubal Cain completed his first engineering job, I think that we shall be able to assure ourselves that in our own, often humble and unostentatious, way we have not borne an ignoble part in the host of fighters who have opposed, and successfully opposed, the legions which Nature has launched against us.

Mr. W. G. Phillips (Atherstone), in proposing a vote of thanks to Mr. Binns for his Address, said that the members would

agree with him that it was of a most interesting character. He had carried their minds very much further into the future than they were likely to travel themselves. Those, however, who might live to see their power obtained from Niagara Falls would probably realize that it was a work of supererogation to use it for getting coal, for he did not think that coal would then be required. There had certainly been, during the last quarter of a century, great developments in the science of electricity, and its application to industrial operations, and nowhere had it made itself more useful than in their mining operations.

Mr. A. H. Stokes (H.M. Inspector of Mines, Derby) seconded the vote of thanks.

The resolution was carried unanimously.

DISCUSSION OF MESSRS. W. J. KEMP AND G. A. LEWIS' PAPER ON "GYPSUM IN SUSSEX."*

Mr. G. A. Lewis (Derby) showed a series of photographic illustrations of the Mountfield mine, both above- and below-ground, and of the winding and hauling arrangements.

Mr. G. Elmsley Coke (Nottingham) said that the first gypsum-mine that he surveyed in Derbyshire reminded him of a rabbit warren. The workings were not laid out on any plan: the good stone being got, and the bad left in to support the roof. He asked whether, in Sussex, it was found more profitable to work out all stone and use the unsaleable marls for packing. He remembered, when the Sussex gypsum-mines were being developed, that it was found very difficult to compete with gypsum from the other side of the Channel, which was worked on a cliff side, and was glad that it had been found possible to successfully do so. The writers' remarks on the bore-hole emphasized the difficulty of proving a new district on the results of one experiment.

Mr. W. Price Abell (Duffield, Derby) said that it was interesting to know of a gas-engine being used for the intermittent work of winding, and he asked whether any practical difficulty had been experienced with it.

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 449.

Mr. R. F. Percy (Nottingham) remarked that it was interesting to hear of a case of winding with a gas-engine. He had recently had occasion to visit a fullers'-earth mine in Bedfordshire, where he was surprised to find that a petroleum-engine was used for winding. Anthracite was used in the drying sheds and coal of any kind was expensive. This was not the only reason for not using steam-power, as there was no water-supply of any kind upon the works. The shafts, lined with bricks laid without mortar, were quite dry, and water could not be procured from the mine. There were no gas-works or gas-mains in the neighbourhood, and, under the circumstances, the use of petroleum was adopted. A single engine, by means of shafting, was able to give power for crushing and pulverizing the fullers' earth, as well as for hoisting it from a depth of nearly 100 feet.

Mr. H. R. Hewitt (H.M. Inspector of Mines, Derby) asked what kind of gas was used for driving the gas-engines. Was it manufactured by a gas-company for lighting and power purposes, was it natural gas (as found at Heathfield and elsewhere in the neighbourhood), or was it producer-gas made on the premises from an inferior coal? To his mind the winding of men with an automatic throw-out was fraught with considerable danger, as these automatic arrangements had a way of going wrong when they were most required. Had any case of overwinding ever occurred, and had the automatic throwing-out gear ever been required to come into action, and with what result? This automatic arrangement was placed some distance inside the gear, and was in consequence difficult to examine properly; in fact, he did not see, from the description given, how it was possible to examine it, as the authors stated that, if it ever got out of order, the whole of the machinery would have to be taken down. Surely this machine could not be depended upon, even though the winding was done at a very slow speed. The petroleum-engine used at the fullers'-earth mine in Bedfordshire, referred to by Mr. R. F. Percy, did all the work on the surface in preparing the mineral for the market. By means of shafting and belts, it worked a crab used for drawing the mineral from the mine, which was 90 feet deep. All the workmen, however, were raised and lowered by means of a hand-power winch, worked by two men, the petroleum-worked gear never being used for this purpose.

The working of the mine was done in a very different manner from what was possible in the gypsum-mines of this district, where the longwall system was impossible owing to the great thickness of the seam, and the numerous wash-outs of running marl, sand, and water, which, when tapped, were left alone as soon as the discovery was made of their existence. The ventilation of this mine would be an easy task, whereas the similar mines of this district were considered to be somewhat difficult to clear of gunpowder-smoke and the products of perspiring men and candles, for reasons which he would not at the present time state.

Mr. P. BEAUMONT (Church Gresley) asked whether the roof was so good that timber was not required; and whether any shock was felt in the cage when the winding-apparatus, driven by the gas-engine, came into use.

The PRESIDENT (Mr. G. J. Binns) said that the authors stated that the "white gypsum" was "absolutely-pure crystallized sulphate of lime;"* the "grey gypsum" was, to a great extent, "almost equally pure,"† and "anhydrite" was only found in the sludge from the boilers; and this was all artificially produced.‡ An average analysis showed slight mineral impurities and 0·2 per cent. of water. Gypsum included 20·93 per cent. of water, and he did not understand how pure crystallized sulphate of lime could contain 0·2 per cent. of water, and how it could be gypsum unless it contained the correct proportion of water. It seemed to him that the so-called "gypsum" (omitting the 0·2 per cent. of water, which was probably hygroscopic moisture and not water of crystallization) must be anhydrite. It would be interesting to know the position of the Sussex gypsum in the scale of hardness: gypsum being 1·5 to 2, while anhydrite was 3 to 3·5.

Mr. G. ALFRED LEWIS (Derby) in replying to the discussion, said that Mr. Coke's remarks about the bad stone being left in the Derbyshire mine indicated the great difference between gypsum in the Midlands and in the south, in Sussex, or in the north, near Carlisle. In the Midlands, gypsum consisted of spherical nodules, which really constituted the seam, lying close to one another, and, here and there, actually touching. These

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 450.
† *Ibid.*, page 451. ‡ *Ibid.*, page 457.

spherical lumps were worked, and wherever it was necessary to go from one lump to another, the road was driven through the intervening useless strata. The workings were extended in all directions without any fixed rule or law, and the gypsum-mine was simply, as Mr. Coke described it, one continuous rabbit-hole. In Sussex, the gypsum-bed was practically of the same quality throughout, and could be worked on the longwall system. The mine had had a chequered career until about ten years ago, when his friend, Mr. Kemp, introduced a spiral process for the manufacture of plaster. A great deal of what had previously been regarded as waste material was utilized; the gob was worked over, and 60 per cent. of what had hitherto been called " rubbish " was extracted and manufactured into a marketable commodity. There was no difficulty whatever in stopping or starting the gas-engine, and, the cage having to move only 150 feet, up and down the shaft, it had necessarily to move at a slow speed; therefore any accident which caused a sudden stoppage would have practically no effect by reason of its suddenness. The gas was made by the Dowson process, from anthracite peas, with a receiver placed between the producer and the gas-engine, whereas in the most modern form of suction gas-producer a receiver was not necessary. There was a system of clips upon the guide-rods which would come into action upon a breakage of rope or other similar accident. These clips were tested very frequently, and on no occasion had they been known to fail. No accident had happened, and the plant was always found in good condition. On the other hand, an accident would not entail an actual stoppage of the whole mine, because the other shaft could be put into use in a few minutes. A large stock of stone was kept on the surface, so as to provide for any emergency caused by accident. It was a curious fact that, on one side of the mine, the packs were built close up to the face, the roof was extremely good, and no timber was used. On the other side, however, an overlying bed that looked like a sponge had to be taken down, and a large quantity of timber had, in consequence, to be used.

Mr. L. C. Kemp (Robertsbridge) wrote that the winding-engine was driven at 220 revolutions per minute by two belts, one open and the other crossed, both running on loose pulleys with a fast pulley between them. The speed was reduced by a triple reduc-

tion-gear to 12 revolutions per minute on the rope drum, which gave a speed of 200 feet per minute to the cages. The self-sustaining apparatus was on the intermediate shaft, *A* (fig. 1), of the triple reduction-gear. This consisted of a hollow cylinder, not shown in the sketch, 12 inches long, 16 inches in external diameter, and 12 inches in internal diameter, and was fixed to the frame of the engine, central with the intermediate shaft, which passed through it. Two loose ends, *F* and *G*, 16 inches in diameter, were keyed to the shaft with keyways, *C* and *D*, too wide for the keys, thus allowing circumferential movement. The keys were fixed to the shaft. Joining the two loose ends, and passing through the cylinder, were four chains, *E*. If now one loose end was moved round the shaft, the chains would be skewed, thus tightening the two loose ends against the cylinder ends and forming a brake. If a full cage, *W*, were coming up, and an empty going down, the two keys would be hard up against their keyways, as shown at *C* and *D*. If now the belt was struck off, the full cage would run back, driving the intermediate shaft, taking the key off the keyway face at *D*, revolving the loose end, *F*, and skewing the chains, thus bringing the brake into operation. The dotted lines at the keyway, *D*, showed the position that the key would have in the keyway when the brake was on.

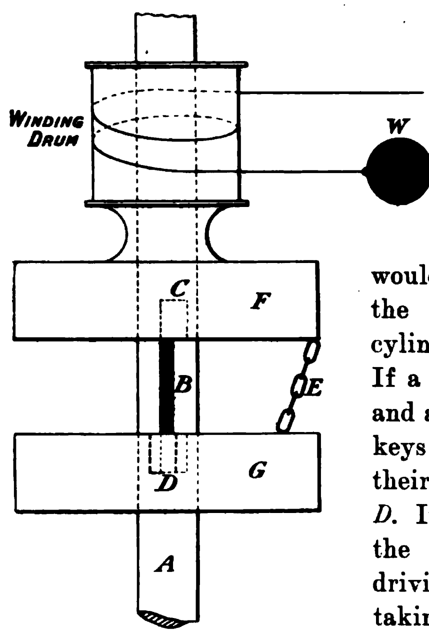

FIG. 1.—AUTOMATIC THROW-OUT GEAR.

The inside faces of the two loose ends, and also the ends of the cylinder, had V-shaped concentric grooves turned in them to increase their area of friction. By removing eight $\frac{5}{16}$ inch nuts, the ends could be slid back along the shaft, exposing the interior of cylinder, faces, and chains for examination. The cylinder was kept full of tallow, and the friction faces were lubricated with grease. As to the automatic knock-off gear, the drum-spindle was

prolonged, and carried a wheel which moved the belts on and off. Both spindle and wheel were threaded, and nuts were fixed on the spindle at any pre-determined place, which, as the spindle ran through the wheel, came up to the boss and turned it round and struck off the belts. This last was only set as an emergency knock-off, and had never been used except to test it occasionally, when it had always acted perfectly. This gear had been in constant use at the mines for three years, and no accident of any kind had as yet occurred. A similar gear was in use at the Crystal Palace for taking people to the top of the water-chute, and carried many thousands of passengers without accident.

DISCUSSION OF MESSRS. W. N. ATKINSON AND A. M. HENSHAW'S PAPER ON "THE COURRIÈRES EXPLOSION."*

Mr. W. MAURICE (Hucknall Torkard) wrote that it had been officially stated that the primary cause of the Courrières disaster was unknown; that neither the employment of naked lights instead of safety-lamps in the Lecœuvre heading, nor the use of No. 1 Favier powder instead of safety-explosives stood in the relation of cause and effect. It was further stated in the report of Mr. O. Delafond† that as regarded the coal-dust danger, neither the experiments made, nor the teachings of practice, permitted them to suspect the possibility in a non-fire-damp mine of an inflammation of such dimensions; the explosions of coal-dust alone in the absence of fire-damp, hitherto registered in France, having never extended beyond distances of 160 to 260 feet (50 to 80 metres) from their point of origin, with the single exception of the Decize mine (180 metres), in the accident of February 18th, 1890.

The object of this discussion was not, he thought, to add to the number of theories designed to explain the unexplainable, but to extract from the evidence before the members some grains of fact whereon to base for themselves rules for the prevention of similar disasters. It was an unquestioned fact that an explosion took place; and he thought it was also unquestioned that,

* *Trans. Inst. M. E.*, 1906, vol. xxxii., pages 439, 340, and 507; 1907, vol. xxxiii., pages 124, 303, and 326; and 1907, vol. xxxiv., pages 151 and 168.

† *Journal Officiel*, Paris, August, 1907.

whether initiated in the presence of fire-damp or not, the explosion was essentially an explosion of coal-dust. He did not see that it mattered precisely how this explosion was initiated. If there was a sufficiently thick cloud of dust in the air and a light was applied, it would burn. This, like most of the early experiments with coal-dust, was a demonstration of the obvious. If, however, this simple dust-ignition occurred in a confined space, the gaseous products of the ignition furnished with the remaining air an explosive mixture, which was ignited and exploded by the flame of the burning dust. Experiment had shown that air containing as little as 4½ grains of coal-dust per cubic foot would ignite and explode. In the presence of about 1 per cent. of fire-damp, that was to say, of a quantity which would not be detected by any miner's safety-lamp in general use in this district, the weight of coal-dust necessary to produce an explosive mixture was still further reduced. Mine-air did not, however, commonly carry as much as 4½ grains of coal-dust per cubic foot and consequently the danger from direct ignition of the atmosphere by flame was so remote as to be quite negligible. A local ignition of gas might, however, raise sufficient dust to burn and provide an initial explosion, which latter would continue to raise and explode dust so long as there was sufficient heat to convert fresh dust into gases and such an atmosphere as would combine with those gases to form an explosive mixture. The most obvious remedy for this danger to his (Mr. Maurice's) mind was not to remove the dust but to remove the naked light. Having removed the naked light which might be present as an illuminant, it remained to bear in mind that even permitted explosives (and more emphatically those which were not permitted) might, under certain conditions, become equivalent to naked lights. If all these conditions were known, and could be controlled, the dust-danger would be eliminated from the risks of coal-winning.

Unfortunately there still remained a great deal to be learnt, for instance, as to the exact nature of the process of combustion during the explosion of blasting agents. Mr. Le Chatelier formulated a theory of chemical reaction which taught that when such reactions were in progress there was a tendency to compensate for changes by means of other changes of an opposite order. In this and in similar directions, mining engineers must look to those

who were engaged in scientific research for indications in the development of perfectly safe explosives.

The nearest danger, he thought, was that caused by blown-out shots, whereby the burning products of combustion were ejected, as from a cannon's mouth, into the air of the mine. Probably it would add to the general safety in this respect if the principle of the *charge limite* were adopted, and some further enquiry made as to the length and kind of stemming most suitable to be used with each class of explosive. If beyond this, mining engineers adhered literally to the existing rules as to shot-firing in main-roads, he could not but think that the extended treatment of dust, either by watering or other methods, was entirely superfluous.

Mr. A. H. Stokes (H.M. Inspector of Mines, Derby) said that it was desirable that the discussion should be adjourned, and not concluded that day as was intended. They had not yet heard what the French mining engineers had got to say, and he thought that they ought to wait until their opinions were available. So far, he had heard nothing to alter the opinion that he had previously expressed.* Indeed, all he had read had been rather to confirm him in his suggested explanation, namely, that something at or near the fourth air-pipe was the primary cause of the explosion. Another point was also worthy of consideration, and that was the isolation of districts; and managers who had a number of mines should be careful to keep them isolated as much as possible.

Mr. W. G. Phillips (Atherstone) said that he should like to know something of the condition of the parallel heading above the main heading where the explosion occurred. Those headings were in a position where there would not be too much ventilation under any circumstances, and the parallel heading had not been working for two days before the explosion. He was strongly convinced that there was an accumulation of gas in the parallel heading, that it found its way to the main heading, and that it was fired by some means in or about the vicinity where Mr. Stokes suggested that the explosion had its origin.

Mr. H. R. Hewitt (H.M. Inspector of Mines, Derby) said he did not see what further information they were likely to get

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 241.

in the future to assist them in the elucidation of the cause of this great calamity. He had read the report of Mr. O. Delafond, Inspector-General of Mines, which was read before the Conseil-Général des Mines on May 3rd, 1907, and that body came to certain conclusions and made certain recommendations, based upon the report placed before them, and he did not see what further information would be gained to throw additional light upon the matter.* The Conseil Général des Mines conclude their enquiry by saying that "in consideration of the publications that have already appeared abroad concerning the catastrophe, and the technical lessons that are suggested by established facts," they appointed Mr. Heurteau, Inspector of Mines, to compile a history. A history of a matter of this kind would, he presumed, be the known facts, and a compilation of the opinions, already expressed at the discussion, of various mining societies in France and elsewhere with a view to closing the matter.

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* *Journal Officiel*, Paris, August, 1907.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE CENTRAL HALL, DONCASTER, NOVEMBER 27TH, 1907.

MR. J. R. R. WILSON, PRESIDENT, IN THE CHAIR.

The minutes of the previous General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

MEMBERS—

Mr. SAMUEL S. ATKINS, Colliery Manager, Treeton Collieries, Treeton, Rotherham.

Mr. WILLIAM STEVENSON BLACKBURN, Colliery Manager, Allerton Main Colliery, Woodlesford, near Leeds.

Mr. JOHN RICHARD FARRER, Mining Engineer, Ledstone Mill, near Castleford.

Mr. HENRY JOHNSON, Assistant Manager, Whitwood Collieries, Normanton.

Mr. GERALD A. OGILVIE, Mechanical Engineer, c/o Messrs. Percheron, Ogilvie & Company, Engineers, 173, City Road, London, E.C.

Mr. GEORGE ALBERT ROBERTS, Civil Engineer, 37, Richmond Mount, Headingley, Leeds.

Mr. HUGH FENKMAN SMITHSON, Mining Engineer, New Silkstone and Haigh Moor Collieries, Allerton Bywater, Castleford.

Mr. REGINALD BARRATT WOOD, Mining Engineer, Wharncliffe Chambers, Bank Street, Sheffield.

ASSOCIATE MEMBERS—

Mr. GEORGE CHRISP, Analytical Chemist, Dalton Main Bye-product Coking Plant, 12, Silverwood Terrace, Thrybergh, near Rotherham.

Mr. R. J. EVANS, Managing Director of Colliery Company, Dalton Main Collieries, Rotherham.

Mr. FREDERICK HENRY INGLE, Administrator-General, Neuquen Proprietary Gold-mines, Chos-Malal, Territorio Nacional del Neuquen, Argentina.

Mr. G. LIVINGSTONE, Engineer, Fern Bank, Coniscliffe Road, Darlington.

Mr. EUSTACE MILNE MILNE, Mechanical Engineer, Calderley House, near Leeds.

Major J. Reginald Shaw, Colliery Proprietor, Purston Hall, Pontefract.
Mr. W. H. Yardley, General Manager, Messrs. Princeps & Company, Sheffield.

Students—

Mr. Tom Brown, Mining Student, 506, Dulesgate, Todmorden.
Mr. Harold Newton Earl, Mining Student, Wales Vicarage, near Sheffield.

THE LATE MR. M. WALTON BROWN.

The President (Mr. J. R. R. Wilson) said that The Institution of Mining Engineers had lost its Secretary, Mr. M. Walton Brown having died very suddenly on November 22nd. There was no question that Mr. Brown had been a most efficient Secretary. He was a very able man, a reader, a very thoughtful man, and a hard worker. Sometimes they might have clashed in their opinions, but they were always ready to admit that he had weight on his side in whatever he did. Though they might not agree with him, they were always convinced that he was perfectly satisfied in his own mind that, in doing what he did, he was doing the right thing. The Council had passed the following resolutions, which he asked the meeting to support:—

(1) "That the Council of the Midland Institute of Mining, Civil and Mechanical Engineers desires to place on record its deep sense of the loss that The Institution of Mining Engineers has sustained by the sudden death of Mr. Martin Walton Brown, who, with characteristic zeal and ability, has for many years so efficiently occupied the position of Secretary."

(2) "That the Council desires to express its deep sympathy with the family of the late Mr. M. Walton Brown in the loss that they have sustained by his sudden death."

Both resolutions were unanimously confirmed, the members rising in silence in token of assent.

APPOINTMENT OF MR. J. R. ROBINSON WILSON AS H. M. CHIEF INSPECTOR OF MINES FOR INDIA.

Mr. W. H. Chambers (Conisborough) moved the following resolution:—

"That the members of the Midland Institute of Mining, Civil and Mechanical Engineers desire to offer hearty congratulations to their President, Mr. J. R. Robinson Wilson, on his appointment as H.M. Chief Inspector of Mines for India, and to place on record their high appreciation of the valuable services which he has rendered to the Institute."

Mr. Chambers said that he was sure every member would agree most sincerely with everything that the resolution contained. They knew the very active interest which Mr. Wilson had, for many years, taken in the welfare of the Institute, and his election to the Presidential chair was almost a compulsory recognition on their part of the work that he had done. Now they all felt exceedingly glad that they offered that recognition when they did. Whilst they would feel Mr. Wilson's absence, they were quite sincere in their congratulations. The Institute, as a body, wished Mr. Wilson health and strength to carry on his work in the efficient manner in which they knew he would perform it, provided that he had that health and strength. In addition to what Mr. Wilson had done for the Institute, they, as practical managers of mines, knew that he had exercised very eminent ability in assisting what, after all, was one of the Institute's chief objects, the preservation of life and property in mines. He had great pleasure in moving the resolution..

Mr. P. C. Greaves (Wakefield), in seconding the resolution, claimed that Mr. Wilson's appointment was a matter of congratulation to Yorkshire, for he was practically a Yorkshireman. During the fifteen years that he had been in the county he had met them all, and had not made a single enemy. If there had been a difficulty, he had always helped them out of it; and he had been most courteous at all times. During the time that Mr. Wilson had been President, their membership had increased wonderfully, and he could only ascribe the increase to the advice which Mr. Wilson had at all times given—that it would be to the welfare of Yorkshire if every colliery manager were connected with the Institute.

The resolution was carried amid applause.

The President (Mr. J. R. R. Wilson) thanked the members for the way in which the resolution had been received. He had considered it a great honour to be President of that Institute, and an honour also to be an inspector in Yorkshire. Under ordinary circumstances his term of office would not expire until June next, but the Council had nominated Mr. W. Walker, H.M. Inspector of Mines, to fill the vacancy which his (Mr. Wilson's) removal would create. That recommendation would have to be

confirmed by that meeting. On behalf of the Council, he submitted Mr. Walker's name for election as President during the remainder of the current year.

The recommendation was unanimously confirmed by the meeting.

Mr. W. Walker (H.M. Inspector of Mines, Doncaster) thanked the meeting for having elected him President in Mr. Wilson's place. He asked to be allowed to join in all that had been said respecting Mr. Wilson, who had always been a loyal supporter and a good friend.

Mr. W. Walker read the following "Notes on Two Incidents with Explosives at the West Riding Collieries, near Normanton":—

NOTES ON TWO INCIDENTS WITH EXPLOSIVES AT THE WEST RIDING COLLIERIES, NEAR NORMANTON.

By W. WALKER.

Incidents.—Two instances of charges of Nobel carbonite, which it was attempted to fire with Orion (No. 6) detonators, being ignited instead of detonated, occurred at the West Riding collieries on June 20th and July 10th, 1907. Such occurrences are, so far as the writer is aware, fortunately rare; and the results which may arise from them are of such importance that he thinks a description of them may be of interest to the members, and lead to a discussion which will give them the benefit of the experiences of other users of explosives of a simliar character, and at the same time suggest the best means to be adopted for the prevention of such accidents in the future.

Nobel carbonite is manufactured by Nobel's Explosives Company, Limited, and, to comply with the Explosives in Coal-mines Order, must consist of the following mixture:—

Ingredients.	Parts by Weight.	
	Not more than	Not less than
Nitro-glycerine	27·0	25·0
Nitrate of barium	4·5	3·5
Nitrate of potassium	32·0	28·0
Wood-meal	42·0	39·0
Sulphuretted benzol	0·5	—
Carbonate of sodium / Carbonate of calcium	0·5	—

The wood-meal must contain not more than 20 per cent., and not less than 10 per cent. by weight of moisture.

The Orion detonators were supplied by the Roburite Explosives Company, Limited, of Gathurst, near Wigan. This detonator consists of two parts: an upper one of cardboard, fitted to the outside of a lower one of copper, and attached to it by means of cement. The fuze-head containing the flashing-

powder is fixed in the upper portion, and the fulminate of mercury in the latter. The construction of these detonators is shown in fig. 1 (plate v.): *a* represents the copper-capsule; *b*, the cardboard-cap; *c*, the sulphur sealing; *d*, metal strips soldered to the ends of the wires, which are kept the correct distance apart by a piece of paper; *e*, the priming compound; and *f*, the fulminate of mercury.

(1).—The first incident occurred in the Diamond seam on a horse haulage-road. A vertical hole, *ab*, 1¾ inches in diameter and 16½ inches long, bored in the roof to remove a piece of stone at the side of the road (fig. 2, plate v.), was charged with 2 ounces of carbonite, *a*; the detonator was placed at the top-end of the charge; and the wires were fastened to it by a half-hitch round it (fig. 3, plate v.). The hole was stemmed with 12 inches of its own borings. An attempt was then made to fire the shot by a high-tension magneto-battery, but instead of the stone being displaced, the stemming was blown out, and the explosive fell on the floor and burned with a rose-coloured flame. Upon examination, some of the paper-covering was found smouldering on the ground, and the detonator was picked off the floor with a piece of the paper-case of the fuze-head surrounding the neck of the copper-capsule.

(2).—The second case occurred in a shot-hole, drilled with the intention of blowing up bottom-coal in No. 5 gate-road in the east district of the Flockton seam. The hole, *ab*, 4 feet long, was drilled horizontally. It was charged with 2 ounces of carbonite, and the detonator, *a*, was placed at the rear of the cartridge. The deputy, who was firing the shot, retired to a safe distance and coupled the cable to his battery, and on his turning the handle the shot failed to explode. He thereupon returned to the shot, thinking that the wires might have become crossed; but, concluding that this was not so, he again retired to a safe distance, coupled the cable to his battery, and tried to fire the shot. Again there was no explosion, and he returned towards the hole; and, on approaching it, he heard the explosive fizzing, and saw smoke forcing its way through the stemming. He jumped to one side, and almost immediately the detonator exploded. The charge being small, the explosive must

have almost entirely burned away before this occurred. If the charge had been a heavier one, and if a considerable quantity of carbonite had still remained when the detonator exploded, the result in all probability would have been a serious accident.

Experiments.—On several occasions since the first incident occurred, experiments have been made by the manufacturers of the detonators and of the explosive, Mr. W. D. Lloyd (the manager of the colliery) and the writer. Briefly they were of the following description, and the results are given below.

(1) An Orion electric fuze, bared of priming, was used for the purpose of trying what would be the effect of the broken or bared wire on the passage of the current, and, on the third attempt, a cartridge of the explosive was ignited.

(2) A cartridge of the explosive, without stemming, was ignited with an electric fuze only, and it burned away completely.

(3) The same experiment was repeated with the addition that the detonator, which was picked off the floor on June 20th (when the shot-firer found the explosive-charge burning), was plugged and put into the cartridge at the end opposite to that in which the electric fuze was inserted. The explosive was ignited, and burned until it reached the detonator, when the latter exploded and detonated the unburnt portion of the charge.

(4) A charge of 2 ounces of carbonite, with an electric fuze fitted into the top end of the cartridge, was placed in a hole, 10 inches in depth, drilled in a steel block, and stemmed with 5 inches of light stemming. The block was suspended, in order to represent the conditions prevailing in the mine when the first incident occurred. The stemming was at once blown out without a report; and the charge fell on to the ground, burned, and gave off much flame.

(5) The same experiment was repeated, with 7½ inches of damped stemming. Almost immediately the stemming was blown out with a report; and flame from the hole and smouldering of the paper covering of the cartridge was observed.

Possible Causes of Ignition.—From these experiments, the following possible causes of the ignition instead of the detonation of the explosive suggest themselves.

(1) *Applicable to the Incident of June 20th.*—(*a*) When the shot-hole in the pit was charged, the detonator became detached from the electric fuze and fell on the floor without being noticed by the shot-firer; and, in consequence, the explosive was ignited instead of being detonated, producing in the mine conditions similar to the results obtained in Nos. 4 and 5 experiments, and causing flame from the explosive and smouldering paper; or (*b*) the shot was ignited by a short circuit in the fuze-wires, burnt partly away, and blew the stemming out of the hole along with part of the charge and detonator.

(2) *Applicable to the Incident of July 10th.*—(*c*) The detonator became detached from the electric fuze, thereby resulting in the latter igniting the charge; or (*d*) a spark from the wires, owing to defective insulation, ignited the explosive.

(3) *Applicable to both Incidents.*—(*e*) The shot-firer, when inserting the electric detonator-fuze into the carbonite cartridge or when pushing the charge into the hole, may have broken the cardboard cap, thereby moving the detonator to one side and allowing the flashing mixture of the electric fuze to act on the explosive in place of the fulminate in the detonator; if this occurred, the charge would burn until it reached the detonator, and then the remainder of the charge would be exploded; or (*f*) a back-blow through the rear of the electric fuze, owing to some mechanical obstruction sufficient to prevent the flash of the fuze from reaching the fulminate, such as sawdust not properly removed, caused the ignition of the charge.

On the facts being submitted to Captain J. H. Thomson, C.B., H.M. Chief Inspector of Explosives, he expressed the opinion that a possible theory, and perhaps the most probable in view of all the circumstances, was that the ignition of the charge, in both incidents, was caused by a spark from the defective insulation of the wires. The writer, while concurring in this opinion as regards the incident which occurred on July 10th, inclines to the belief that the ignition of June 20th was caused by the electric fuze becoming detached from the detonator when the cartridge was being placed in the shot-hole, and the charge was in consequence ignited by the former.

Mr. H. Bigg-Wither, general manager of the Roburite Explosives Company, Limited, the makers of the detonators, explains that it is practically impossible for any sawdust to be

left in a detonator. The operation of clearing them is effected by turning each box of 100 upside down on to a piece of brass-wire gauze of large mesh. The box is then reversed and the contents examined, when any sawdust is easily noticeable. He had made some experiments with Orion fuzes, with an empty detonator cemented into them; but no flash was noticed to issue from any part of them, and in no case was the cardboard tube burst. The quantity of priming is small, and more of a flaming than of a bursting nature.

Precautions.—The writer is of opinion that the following precautions are necessary, especially with explosives containing nitro-glycerine, as they are more liable to ignite than nitro-ammonia compounds.

Upward vertical holes should, as far as possible, be prohibited, as, during the insertion of the charge and in the course of stemming, the detonator is liable to become canted in the cartridge, and thus to become displaced or to come into contact with the sides of the holes and cause an explosion. A fatal accident was caused in this way at Rotherham Main colliery in May, 1905.

The detonators should not be inserted in the rear or between the cartridges of a charge, but always in front of the first cartridge. Care should be taken that the detonator is well bedded in the explosive, and secured, if necessary, by the covering of the first cartridge; and also that the individual cartridges are placed in contact with each other. In addition to the danger of the detonator being canted, if it be put in at the rear end of the charge (the method adopted when both these incidents occurred), four different bends are introduced in the wires (one at the base of the fuze, one at the edge ef the cartridge, and two at the intersection of the half-hitch), thus offering bends in the wires at which the insulation can be injured by rubbing against the sides of the shot-holes and in stemming; whereas, if the detonator is inserted at the outermost end of the charge, the wires are straight and run without bends, and there is consequently much less risk of the insulation being damaged.

The insulation of the wires of electric detonators should be strengthened, as far as possible, in order to prevent any sparks from being emitted, due to defective insulation; and it is important that the two portions of the detonators containing the priming

mixture and the fulminate of mercury should be attached to each other in as secure a manner as possible.

The possible causes of these occurrences open out a wide field for discussion, and the opinion of those who have had considerable experience with explosives and shot-firing is of the greatest value in arriving at the most probable explanation. In nearly all mines conditions exist which make such occurrences highly dangerous; for the risk of explosions of gas and coal-dust being caused by such ignitions of explosives as those described, owing to the large quantity of flame produced, with results disastrous to life and property, is always present. It is with a view of making them known to those of the mining public, who, otherwise, would, in all probability, not become aware of the liability of such incidents and the dangers thereby incurred, that the writer had written these few notes.

Mr. John Neal read the following paper on "An Ignition of Coal-dust at Middleton Colliery":—

AN IGNITION OF COAL-DUST AT MIDDLETON COLLIERY.

BY JOHN NEAL.

There is abundant evidence that coal-dust has been ignited in mines by shots, with and without the presence of inflammable gas. Explosions of fire-damp have been intensified, and, in many instances, a small local explosion or ignition of fire-damp has been converted into a terrible disaster by the presence of coal-dust. The writer believes that there is not on record an instance where it has been clearly proved that coal-dust has been ignited in the mine by means of a simple flame, such as that of an ordinary candle or safety-lamp.

Explosions of coal-dust have occurred where it has not been clearly and satisfactorily proved that either shot-firing or inflammable gas has been responsible for their initiation, and it is not improbable that on more than one occasion these agents have had nothing to do with them. It is by no means the general impression that coal-dust, as found in the mine and under ordinary working conditions, can be ignited by a simple flame. On the contrary, mining engineers have thought that nothing short of an ignition or an explosion of gas, gas and dust, or a blown-out shot, could start a coal-dust explosion; and this was, to some extent, the writer's opinion until the ignition described in this paper took place.

On September 2nd, 1907, an ignition of coal-dust occurred in the Beeston seam, at Middleton colliery. This seam is very dry, and a considerable amount of dust accumulates very rapidly in the roads despite constant cleaning. About noon, a deputy had opened a safety-lamp at the lamp-station, A (figs. 1 and 2, plate vi.), for the purpose of relighting another lamp. At the same time, a train of full tubs, drawn by a pony, was passing, and raised a considerable quantity of dust from the floor.

Just before the train reached the lamp-station, the deputy removed part of the burning snuff or snod from the lamp, and it

fell harmlessly to the floor. As soon as the train had passed, he knocked away the remaining portion of the snuff; and, as this fell to the floor, there was an ignition of the dust. Whether the dust ignited was dust from the floor, or that blown and shaken from the train, or both, the writer is not prepared to say. The flame rose from the floor to a height of about 2¾ feet, and spread over a width of about 3 feet (figs. 3 and 4, plate vi.). It followed the train with a peculiar rolling motion apparently corresponding with the successive clouds of dust raised, and made a strange hissing sound similar to that of a firework squib.

The train stopped at a point, B, about 45 feet beyond the lamp-station; and, when the flame reached the last tub, it ascended to the roof, returned along the upper portion of the roadway, and finally extinguished itself within 3 feet or so of the point of ignition. The colour of the flame was described by the deputy as being similar to that of a candle or oil-lamp.

A piece of brattice-cloth, *a*, nailed to the back of the lamp-station and used by the turnkeeper as a blackboard, was set on fire; otherwise no damage was done, and no person was burned.

The ignition was also witnessed by the turnkeeper, who was standing near at the time. He confirmed the deputy's statement in every particular.

The course of the ventilation is shown on the plan (fig. 1, plate vi.). At C, some distance outbye from the lamp-station, there are two doors, and this road is ventilated by a scale of air through them: the quantity passing being 1,300 cubic feet per minute. This split is taken from the main intake-airway, and ventilates this road only before it joins the main body of air about the district, at the entrance to the main return-airway about 2,000 feet inbye.

Inflammable gas is very rarely found in the Beeston seam, and never in large quantities. The report-books show that gas had been found only twice during the last 12 months in the whole of the mine, and not once in this particular district. It is extremely unlikely that gas, either accumulated or in the ventilating current, could be present at this place.

The writer visited the place soon after the occurrence, and could not find any trace of gas. He has examined it many times since, and he has been unable to detect the slightest trace, even with a gas-detector capable of indicating ¼ per cent.

The readings of the barometer from August 26th to September 6th, 1907, are recorded in Table I. It is interesting to note that,

TABLE I.—READINGS OF THE BAROMETER FROM AUGUST 26TH TO SEPTEMBER 6TH, 1907.

Date, 1907.	6 a.m.	2 p.m.	10 p.m.	Date, 1907.	6 a.m.	2 p.m.	10 p.m.
	Inches.	Inches.	Inche		Inches.	Inches.	Inches.
Aug. 26	29·72	29·70	29·78	Sept. 1	?	?	29·72
„ 27	29·70	29·76	29·80	„ 2	29·50	*29·35	29·15
„ 28	29·80	29·90	29·68	„ 3	29·30	29·40	29·50
„ 29	29·60	29·70	29·65	„ 4	29·50	29·65	29·65
„ 30	29·80	29·80	29·82	„ 5	29·37	29·50	29·55
„ 31	29·70	?	?	„ 6	29·75	29·70	29·76

* Ignition occurred at mid-day.

on the day of the ignition, the barometer was at the lowest point of the whole period recorded. The fall was gradual from 10 p.m. on September 1st to 10 p.m. on September 2nd, when it reached the lowest point: the total fall being 0·57 inch. This reduction of pressure would account for an increase in the volume of about 2 per cent., and had it been possible for any reservoir of gas to be present, the increase, spread out over a period of 24 hours, could not, in the writer's opinion, have had any influence upon the ignition. The probability of the existence of any such reservoir of gas is very remote. There are no open goaves in the workings, the gob having been packed solid, and at the point of ignition the workings have been settled for many years. It is not likely that any gas, which might be contained in the fissures above the roof and held back at atmospheric pressure, could by reason of the decrease in pressure flow out into the roadway to such an extent as to have any influence upon the ignition.

In considering the possibility of the presence of gas, the writer recurs to the fact that the flame in the first instance travelled along the floor to a height of about 2¾ feet, and he believes that, if gas had been present in such quantity as to influence the ignition at this distance from the roof, the result would have been a violent explosion, sufficient to dislodge the dust resting on the bars and sides of the roadway and further to extend the area of the explosion. The dust on the tops of the bars was not disturbed; but the return-flame had removed the dust adhering to the sides of the bars.

Analyses of samples of dust from the screens at the surface and the haulage-roads in the mine are recorded in Table II. The dust from the haulage-roads was collected, from the props and bars, at various distances from the pit-bottom.

TABLE II.—ANALYSES OF SAMPLES OF COAL-DUST.

No.	Place where Sample of Coal-dust was Collected.	Distance in-bye from Pit-bottom.	Volatile Matter.	Fixed Carbon.	Ash.	Ratio of fixed Carbon to Volatile Matter.
		Feet.	Per cent.	Per cent.	Per cent.	
1	Screens at surface	—	23·43	58·82	17·75	2·51
2	Safety-boards at pit-bottom	—	24·74	58·61	16·65	2·36
3	Props and bars at entrance to main haulage-road.	0	25·67	58·08	16·25	2·26
4	Main haulage-road	1,860	25·24	41·71	33·05	1·65
5	do.	3,100	21·73	37·92	40·35	1·74
6	do.	3,960	22·97	32·43	44·60	1·41
7	do.	5,280	22·15	36·40	41·45	1·64

Mr. J. R. R. WILSON (Leeds), in proposing a vote of thanks to the writers of the papers, said that there were one or two rather obvious points to which he should like to draw attention. In the first paper, the fault seemed to lie entirely with the detonator; was its construction commendable? Regarding the second paper, the question arose as to the proper position for a lamp-station; was it upon a main haulage-road? Was it advisable to use a type of lamp of which the bottom could be screwed off, and the snuff thrown upon the floor? Was it not a distinct advantage to have the lamps lighted and relighted internally by electricity?

Mr. H. BONSER (Leeds), in seconding the vote of thanks, said that the incidents were most remarkable. In the case of the incident of June 20th, the explanation appeared to be that, during the preparation of the shot, the detonator had become detached from the fuse-head and had fallen on the floor unperceived by the shot-firer, and in consequence the explosive was ignited. In the case of the incident of July 10th, there were two probable explanations:—(1) The detonator had become detached from the fuse-head, the result being that the latter ignited the charge; or (2) that the shot-firer, when inserting the fuse into the cartridge, had broken the cardboard cup, thereby removing the detonator to one side and allowing the flashing-mixture of the

fuse-head to act on the carbonite in place of the fulminate in the detonator. The explosive would then burn until the detonator was reached, when the remainder of the charge would explode.

Prof. G. R. Thompson (The University, Leeds) asked what was the method of firing and the voltage of the current, as this would have some bearing on the question of short-circuiting in the wires causing the ignition. The distance across which a spark could form in air was very small, although when the spark had been established the distance apart of the wires might be much increased, and, if a sufficient quantity of electricity were available, it would still ignite the charge. The first case of misfire appeared to be satisfactorily explained in the paper. With regard to the second case, he referred to a paper read by Mr. H. Bigg-Wither before The Institution of Mining Engineers some time ago,* in which he showed that detonators subject to damp became less efficient, and might lose power to such an extent as only to be capable of bursting the copper-capsule. He (Prof. Thompson) would suggest as an alternative explanation of the second case that the detonator used was of insufficient power to detonate the explosive, and simply ignited it, giving the same effect as is produced by the use of a powder-fuse with high explosives.

Mr. W. H. Pickering (H.M. Inspector of Mines, Doncaster) thought that there were a good number of cases on record similar to those described by Mr. Walker, and he was rather inclined to think that the explanation suggested by Prof. Thompson was the correct one in the second case. He regarded both papers as valuable contributions to the records of the Institute, as they were records of what actually took place, and not mere theories. There were, however, records of dust having been ignited in a similar manner before. In a short paper that he communicated to the Institute some time ago,† he gave three instances of dust-firing, two by sparks, and one by friction in a pulley, and agreed with Mr. Neal that this was an absolute ignition of the dust. In the discussion on his (Mr. Pickering's) paper, an instance was given of dust having been ignited by gas-lamps at the bottom of a pit.‡

* "Notes on Detonators," *Trans. Inst. M. E.*, 1901, vol. xxi., page 442.

† "The Dust-danger," *Trans. Inst. M. E.*, 1905, vol. xxix., page 134.

‡ *Ibid.*, page 140.

explosion occurred. He was interested in Mr. Walker's view as to how detonators should be inserted in cartridges, but entirely failed to agree with that gentleman's opinion that the detonator should be inserted in the primary cartridge. Where two cartridges were used, he had made it an unfailing rule to put the first cartridge into the hole blank, and to insert the detonator into the back end of the second cartridge, turning the wires along the hole, thus ensuring a buffer between the back of the hole and the detonator and between the detonator and the tamping-rod. His experience of putting the detonator in the front end of the first cartridge was that frequently the detonator was withdrawn by the pressure of keeping the wires tight during ramming; and if, to avoid this, the fuse-wires were allowed to be slack, there was the danger of kinking the wires and thus causing short-circuiting.

With regard to Mr. Lloyd's claim that one misfire in 750 was good, and the information given by him that high-tension fuses were used, he (Mr. Hodges) suggested that, if low-tension fuses had been used, Mr. Lloyd might have expected one misfire in 2,000.

Mr. Neal's paper was interesting as being the actual record of an ignition of coal-dust as seen by an eye-witness. It had been wellknown to many of them that coal-dust had been frequently ignited in the absence of gas in the old candle days. He quoted an instance occurring 30 years ago, at Manners colliery, and said that there must be many records of events of a similar nature. After all, such ignitions depended considerably upon the nature of the coal-dust. He must say that he was surprised at the analyses quoted by the writer, showing so large a proportion of non-combustible matter in the dust taken from the main haulage-roads. The phenomenon that "the dust on the tops of the bars was not disturbed; but the return-flame had removed the dust adhering to the sides of the bars,"* was peculiar, but might be accounted for if the dust largely consisted of material disintegrated from the roof. He should be glad if the writer of the paper would give the analysis of the dust stated to be left on the tops of the bars, so as to decide the exact reason of the non-combustion, as the opinion had usually been held that the dust taken from the tops of bars on main haulage-roads was generally the most inflammable.

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 223.

Mr. W. WALKER, replying to the discussion, said that the voltage of the battery by which it was attempted to fire the shots was about 100, and he agreed that it was possible for the occurrences to have been caused as Prof. Thompson had suggested, if the detonators were damp; but he did not think that it was a probable cause. The greater part of the discussion seemed to refer to the position of the detonators in the charges, and he (Mr. Walker) appeared to have struck upon a sore place; but he noticed that the opinion as to where they should be was anything but unanimous. Some advocated placing the detonators at the back of the charge, others between two cartridges; some with half-hitches of the wires, and some without. He still, however, held to the opinion that he had expressed, as he had investigated several accidents where persons had been killed or injured owing to detonators having canted in the shot-hole, and had found that there was more liability of such canting occurring when the detonators were placed at the back of a charge than at the front.

Regarding Mr. Neal's paper, he had investigated the occurrence, and quite agreed with the statement in the paper that no gas was present. He had asked the opinion of Mr. W. N. Atkinson, the Superintending Inspector of Mines in South Wales, who probably knew more about coal-dust than anyone in the country, and that gentleman had said that it was a remarkable occurrence and that he would hardly have thought such an ignition possible. He had certainly never heard of such an occurrence before. He (Mr. Walker) had an experience in 1889 in connection with an explosion in a coal-hopper at Brancepeth colliery. Six men were sent to clean out the hopper, three going to the top and three to the bottom of it. It was a large hopper, measuring 24 by 31 by 36 feet; in the inside of it there were four stages, and the whole arrangement was tied together by iron tie-rods from side to side. Open torch-lamps were used, and were hung near the bottom on these tie-rods. The men on the top had not been brushing the dust down for more than two minutes when there was a violent explosion, the three men at the top being killed, and those at the bottom injured. There could not in that case have been the smallest trace of gas present, because the top was fairly open and the ignition took place at the bottom of the hopper.

Mr. J. NEAL, in replying to the discussion on his paper, said

that, with reference to the suggestion that the ignition was caused by oil, the place near which the incident occurred was not one where lamps were filled, but merely lighted, and he did not think that anybody could find a drop of oil about the place. The oil which they burned consisted of mineral colza one part, and colza proper two parts.

Mr. W. N. ATKINSON (H.M. Inspector of Mines, Bridgend) wrote that Mr. Neal's paper described a very unusual and interesting occurrence, from which it might almost be inferred that, under certain conditions, a dangerous explosion of coal-dust might be caused by a naked light. The way in which the flame followed the tub near the floor seemed intelligible, as there the dust-cloud would be thickest; but why, when the tub stopped, the flame should return along the upper part of the road was not easy to understand. From the occurrence of such a body of flame it was quite conceivable that, under certain conditions, it might have developed into a dangerous explosion.

Rather singularly, in *Mines and Minerals** there was an account of "a peculiar mine explosion," also due to an ignition of coal-dust by a naked light, of which the following is a summary:—

On Thursday, September 12th, there occurred at Mine No. 10 of the Union Pacific Coal Company, Rock Springs, Wyo., an explosion of dust, which in its cause and effects is unique in the annals of coal-mining accidents. It occurred at about 5 o'clock in the afternoon when the miners were preparing to leave the mine. About forty of the mine workers had gathered at the foot of the slope (which is an intake airway driven 1,000 feet at an inclination of 200 degrees), when a trip of empties was started from the top. The coupling between two of the cars had not been properly made, and when the trip reached the head of the slope six of the cars started down the 20 per cent. incline unchecked. By the time they had reached the bottom they had acquired a terrific speed, and collided with a trip of full cars waiting there to be hoisted. Fortunately, the men had gotten out of the way, but the impact created a cloud of dust, raised principally from the floor of the gangway, and this dust was ignited by the lamps of the miners. It appears that the mixture of dust and air was not of a character to produce a violent explosion. There was, however, an instantaneous combustion, which produced sufficient heat to burn more or less seriously every man in the immediate vicinity, but none of them so badly that he was not able to walk or crawl out of the manway.

The force of the explosion was felt more seriously 200 or 300 feet down the gangway, where a miner was thrown violently down, and sustained a broken arm and other injuries. One of the peculiar and fortunate effects of the explosion was the partial wrecking of an overcast a short distance east of the slope. This resulted in a short-circuiting of the air-current, which carried off the products of combustion and prevented any deaths from suffocation.

* 1907, vol. xxviii., page 161.

In his evidence before the Royal Commission on Explosions from Coal-dust in Mines, in 1891,* Mr. J. B. Atkinson (H.M. Inspector of Mines) referred to ignitions of coal-dust by naked lights at Nitshill colliery, where boys amused themselves by igniting small clouds of coal-dust. The writer (Mr. W. N. Atkinson) believed that there were also records of a few such ignitions in continental mines. From the widespread use, especially in the past, of naked lights of all sorts in dusty coal-mines, it must be concluded that it was only under special conditions that such ignitions of coal-dust were likely to occur, and these conditions were worthy of investigation.

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* *First Report of the Royal Commission on Explosions from Coal-dust in Mines; with Minutes of Evidence and Appendices*, 1891, pages 28 and 33, Questions Nos. 773 and 974.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
DECEMBER 14TH, 1907.

MR. JOHN H. MERIVALE, PRESIDENT, IN THE CHAIR.

DEATH OF MR. M. WALTON BROWN.

The PRESIDENT (Mr. John H. Merivale) alluded to the sad death of the Secretary of the Institute, Mr. M. Walton Brown, through which the members had suffered an almost irreparable loss. Sir Lindsay Wood, Bart., the senior Past-President, had hoped to be present for the purpose of moving a resolution of condolence, but had telegraphed his regret that, being detained in London, he was prevented from joining with other members of the Institute in expressing deep sympathy with the family of the late Mr. Brown in their bereavement; and in recording the great loss which the Institute had sustained in being deprived of his very valuable services. Mr. Thomas Douglas and Mr. George May, Past-Presidents, were also unavoidably prevented from being present.

Mr. A. L. STEAVENSON (Durham) moved a vote of condolence with the widow and family of the late Mr. Brown, and, in doing so, suggested that it was possible that the members would shortly have an opportunity of showing their sympathy, in a practical way, by contributing to a testimonial fund. The late Mr. Brown was a most efficient Secretary; always ready to offer any help to the members, and to afford them the benefit of his long experience.

Mr. T. E. FORSTER (Newcastle-upon-Tyne), in seconding the vote of condolence, said that, through spending so much of his time in Newcastle-upon-Tyne, he was frequently brought into contact with their late Secretary, and he was always struck with

the manner in which Mr. Brown would hunt up information and do his best to save the members trouble. They were all extremely sorry that he had been cut off so suddenly, and would, no doubt, endorse the proposal which Mr. Steavenson had foreshadowed by doing all that they could for the benefit of his widow and family.

The PRESIDENT (Mr. John H. Merivale), in putting the vote to the meeting, stated that particulars of the suggested fund would be submitted to the members at a later date.

The vote of condolence was unanimously passed by the members rising in their seats.

Mr. J. G. WEEKS (Bedlington) proposed that the Institute should procure a portrait of their late Secretary, and place it in one of the panels of the Lecture Theatre, and in so doing pay a tribute to the fidelity which Mr. Brown had shown in all his work as well as the assiduity with which he had discharged his duties.

Mr. W. O. WOOD (South Hetton), in seconding the proposal, said that the members would all agree that Mr. Brown was singularly amiable, pleasant, and agreeable, and always did his best to promote the interests of the Institute.

The proposal was unanimously adopted.

The PRESIDENT read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on November 30th and that day, together with the proceedings of the Council of The Institution of Mining Engineers at their meeting on September 4th.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. EDWARD ERSKINE BIRD, Secretary of and Engineer to Messrs. George Elliot and Company, Limited, 16, Great George Street, Westminster, London, S.W.

Mr. JAMES BOOKLESS, Mechanical Engineer, 14, Wilson Terrace, Broughton Moor, Maryport.

Mr. CHARLES ARTHUR CROFTON, Colliery Manager, Wansbeck Colliery Company, Limited, Morpeth.

Mr. JOHN CUMMINGS, Colliery Manager, Hamsterley Colliery, Ebchester, S.O., County Durham.

Mr. WILLIAM ENGLISH, Colliery Manager, North Walbottle Colliery, Newburn, S.O., Northumberland.

Mr. ALAN LEONARD STAPYLTON GREENWELL, Colliery Manager, Windlestone Colliery, Ferry Hill.

Mr. GEORGE HARE, Mining Engineer, Seghill Colliery, Seghill, Dudley, S.O., Northumberland.

Mr. GEORGE HOOD, Colliery Engineer, 9, Agents Terrace, Boldon Colliery, S.O., County Durham.

Mr. CECIL WILLIAM JORDAN, Managing Director of the Goodman Manufacturing Company, Limited, Marlborough House, Marlborough Road, Roath, Cardiff.

Mr. ANDREW KERR, Colliery Manager, New Brancepeth Colliery, Durham.

Mr. GEORGE ROBERT KYLE, Mechanical Engineer, 6, Ravensworth Road, Dunston, Gateshead-upon-Tyne.

Mr. FREDERIC THOMAS MARLEY, Mining Engineer, Damodapore Colliery, Nandi P.O., Raniganj, E.I.R., Bengal, India.

Mr. WILLIAM MAURICE, Mining and Electrical Engineer, The Collieries, Hucknall Torkard, Nottingham.

Mr. CHARLES HERMAN MERIVALE, Mining Engineer, Middleton Estate and Colliery Company, Middleton, Leeds.

Mr. BERNARDINO NOGARA, Elecrical and Mining Engineer, Galata, Constantinople, Turkey.

Mr. SIMON PEDELTY, Mechanical Engineer, Broomhill Colliery, Acklington, S.O., Northumberland.

Mr. ROBERT MCLEOD PERCY, Colliery Manager, Cinnamon House, Ince, Wigan.

Mr. HARRY MACKENZIE RIDGE, Mining Engineer, Owton Manor, Seaton Carew, West Hartlepool.

Mr. RICHARD SUMMERBELL, Colliery Manager, Preston Colliery, North Shields.

ASSOCIATE MEMBER—

Dr. CHRISTOPH GEORGE SIGISMUND SANDBERG, P.O. Box 3807, Johannesburg, Transvaal.

ASSOCIATES—

Mr. JOHN CHAPMAN, Back-overman, Tyzack Street, Edmondsley, Durham.

Mr. WILLIAM CUMMINGS, Colliery Under-manager, Beamish View, Stanley, S.O., County Durham.

Mr. FRANK DAGLISH, Colliery Under-manager, Wilson Terrace, Broughton Moor, Maryport.

Mr. WILLIAM HENRY HUMBLE, Colliery Under-manager, Seafield House, Risehow, Maryport.

Mr. NEVILLE BLACKMORE PADDON, Assistant Master Shifter, Victoria House, New Delaval, Newsham, S.O., Northumberland.

Mr. HENRY ANDERSON RIDLEY, Mechanical Engineer, Burnbrae, Blaydon Burn, Blaydon-upon-Tyne, S.O., County Durham.

Mr. ROBERT ARCHIBALD RUTHERFORD, Colliery Engineer, Wellington Terrace, Edmondsley, Durham.

Mr. THOMAS SHARP, Electrical Engineer, Wilson Terrace, Broughton Moor, Maryport.

Mr. WILLIAM THOMPSON, Colliery Under-manager, Stone House, Broughton Moor, Maryport.

Mr. ISAAC WALTON, Colliery Under-manager, Dovenby, Cockermouth.

Mr. JOHN GILBERT WIDOWFIELD, Master Shifter, Railway Terrace, Edmondsley, Durham.

STUDENTS—

Mr. JOHN VALENTINE BELL, Mining Student, 226, Old Farm, Ouston, Chester-le-Street.

Mr. DOUGLAS ROY BROOKS, Mining Student, 118, York Street, Jarrow.

Mr. EDGAR WALTON DAKERS, Mining Student, Tudhoe Colliery, Spennymoor.

Mr. FRED HERDMAN, Mining Student, 7, Chatsworth Parade, Low Fell, Gateshead-upon-Tyne.

Mr. AUGUST VAN DEN HONERT, Mining Student, Koornmarkt, Delft, Holland.

Mr. THOMAS MAUGHAN, Mining Student, Tudhoe Colliery Office, Spennymoor.

Mr. GEORGE HENRY SIMPSON, Mining Student, 8, Morris Street, Birtley, S.O. County Durham.

Prof. HENRY LOUIS read the following paper "On a Deficiency in the Nomenclature of Mineral Deposits":—

ON A DEFICIENCY IN THE NOMENCLATURE OF MINERAL DEPOSITS.

By Prof. HENRY LOUIS, M.A., A.R.S.M., M.Inst.C.E., F.G.S., etc.

The object of this note is to call attention to the absence in the English language of any word or phrase to describe a phenomenon very common in certain types of ore-deposits. It is well known that the ore-shoots in a mineral vein do not, as a rule, coincide with the dip of the vein, but make an angle with it; in the same way, lenticular masses often are oblique to the direction of maximum dip of the plane in which they lie. We have no word to designate this obliquity in either case, and there seems to be a decided need of some such word which, like the German *Fallen im Feld,* shall define it without a cumbersome circumlocution. In America the term "pitch" has occasionally been applied to this obliquity of the axis of the ore-shoot or of the lenticular mass, as the case may be, and the writer wishes to propose that this word be definitely restricted in the literature of ore-deposits to this particular signification. It would thus suffice, in describing such a deposit, to give the angle and direction of the dip, followed by the angle and direction of the pitch; in both it will be understood that the angle is the angle to the horizontal, and the direction is always the azimuth of the horizontal trace of the vertical plane in which the line of dip or of pitch lies.

This suggestion has a certain practical value, and is not merely academic; every mining engineer with experience in such types of ore-deposit will have met with cases in which a vertical shaft has been sunk with the object of cutting the deposit, but has missed it, because the dip alone has been taken into account, whilst the pitch has been overlooked. It is far easier to leave out of consideration a phenomenon that has not a designation of its own, than one that is thus characterized, and that will in time come to be regularly recorded.

In conclusion, it may be pointed out that all the four characteristics—angle of dip, direction of dip, angle of pitch, direction of pitch—need not always be given fully, because a simple geometrical relation subsists between them. Thus in the subjoined diagram (fig. 1), drawn in isometric projection, let *ABCD* be the plane of the ore-deposit, and let *AC* be the axis of the ore-shoot or ore-lens; then *AD* is the strike, and *AB* the line of dip of the deposit; the angle *ABE* (=d) is the angle of dip, and the angle *ACE* (=p) is the angle of pitch; *EB* lies in the azimuth of the dip, and *EC* in the azimuth of the pitch; let the angle *CEB* between these two directions be =a. Then $\cos a = \frac{\tan p}{\tan d}$. This relation may occasionally prove useful.

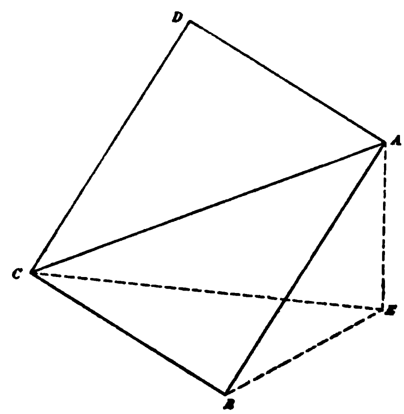

FIG. 1.—ISOMETRIC PROJECTION. DIAGRAM SHOWING DIP AND PITCH.

The writer hopes that his proposal may be found worthy of general adoption, and that to the word "pitch," in the sense here suggested, may be assigned a permanent place in the literature of ore-deposits.

Mr. T. E. FORSTER (Newcastle-upon-Tyne) said that the proposal contained in the paper was one of which anybody accustomed to metal-mining would recognize the necessity, and it seemed curious that it had never been previously put forward. The word "pitch" was sometimes used for dip. "Pitching heavily" was a phrase which meant dipping heavily, but if once the distinction were known, the term would become very useful.

Mr. WILLIAM ARMSTRONG (Wingate) agreed that the suggestion was a valuable one.

Mr. W. O. WOOD (South Hetton) said that in the coal-trade, fortunately, they were not troubled with a complication of the description indicated in the paper.

Mr. A. L. Steavenson (Durham) facetiously remarked that he did not like to allow a paper to pass without objecting to its proposals; there was not much to object to in this instance, but he hoped that they were not going to follow the example of electricians, who had adopted a great number of terms, many of them being misleading. He thought that they had better have too few than too many.

Mr. J. B. Atkinson (H.M. Inspector of Mines) said that, as regarded strike and dip, these were pretty regular and would always occur in a mineral vein, but he understood that pitch was not a regular thing; they did not have a regular deposit, but might have it waving in all sorts of shapes along the line of the vein. Personally, he did not see how the word pitch would meet the difficulty.

Prof. Henry Louis said that if a better word could be suggested he would be glad to employ it. He quite agreed that pitch was not absolutely regular, any more than dip or strike; but if a deposit was said to have a certain dip, this meant the average dip, and he proposed to use the word pitch in the same sense. They must refer to the average in all these cases, and the pitch was at least as regular as the dip in most instances.

The President (Mr. John H. Merivale) said that Prof. Louis had no doubt drawn attention to a want in mining nomenclature. It was a matter which did not come largely within their experience as mining engineers, but the same point had occurred to him as that mentioned by Mr. Atkinson. Dip was not regular; but he was under the impression that it was more regular than pitch, and that the pitch was of very little value as an indication of the position of a deposit one hundred fathoms or so away. He now understood from Prof. Louis that this was not the case, but that it was a very fair guide in searching for the deposit. He had pleasure in proposing a vote of thanks to the writer of the paper.

The vote of thanks was carried unanimously.

The following "Notes on Mining and Engineering in America and Canada" were read by Mr. Walter Rowley:—

NOTES ON MINING AND ENGINEERING IN AMERICA AND CANADA.

By WALTER ROWLEY.

In venturing a few observations suggested by a visit to America and Canada a short time ago, the writer is actuated, not by a spirit of criticism, but rather with a wish to confine his remarks to certain differences in policy, with a view to raising a discussion that may be beneficial to the members of the Institute.

American Mining Laws.—The underground officials at an American mine are styled mine foreman, assistant mine foreman, fire boss and shotlighter. Practically all the American states require an examination for the first two positions, and eight states require an examination for the position of fire boss; whilst the provinces of British Columbia and Nova Scotia require an examination for shotlighters. The position of fire boss is equivalent to that of deputy in this country, and the question is raised as to whether it would not be a step in the right direction to certificate these officials.

In Great Britain, colliery managers' and under-managers' certificates are being granted in large numbers, and for every post that is vacant there are often dozens, if not hundreds, of applicants. There is not the slightest doubt that the granting of certificates has greatly improved the class of men now in these responsible positions, and why should this not be the case with the deputies? With regard to shotlighters, the writer thinks that legislation would also be useful. Turning to surface workers, there are four states that require an examination for the post of hoisting-engineer or winding-engineman. The writer does not think that this is of any advantage. The subject suggests, however, the question of certificating our enginewrights. The extensive use of machinery in mines makes this, in the writer's opinion, desirable; and it seems as though increased efficiency would be the result of relieving a manager of some of the responsibility that he at present carries for the enginewright.

Before leaving the question of the certificated positions, it is interesting to note that some of the states issue certificates to mine foremen of two grades—one for mines where there is no gas, and others for mines which are gaseous. This has sometimes been urged in this country; but, in the writer's opinion, any man holding a responsible position should be well versed in all branches of science appertaining to the positions that he may attain. Although lack of opportunity is undoubtedly nowadays a factor to be dealt with, a man must not be educated to anticipate such a condition of affairs. Knowledge is the principal incentive to ambition, and to put a man into a position only equipped with sufficient knowledge to occupy satisfactorily that one position is to reduce his utility to the world to a minimum. Another point worthy of note is that, in the anthracite district of Pennsylvania, the miner is required to hold a certificate. This, to the writer, is of doubtful value.

With regard to the age of boys who work in mines, which in the United Kingdom is 14, it may be interesting to notice that in the anthracite mines of America the minimum age is 16. The question of age limit is largely an economic one; it seems in certain cases in America to operate with some hardship, and, indeed, a boy leaving school at, say, 13, and put to some other employment, gets into a certain routine, and it is unlikely that he would break this off to go to the mine. Of course, the obvious method is to employ boys first round about the surface of a mine, and then to draft them into the mine.

Output and Accidents in American Coal-mines.—It will, of course, be pointed out that English mines are much freer from accident than American mines, and under this head the writer would quote from a recent statement by Mr. D. W. Williams, United States Consul, Cardiff, as regards the conditions in the two countries for the year 1904*:—

	America.	United Kingdom.
Tons of coal produced	352,310,427	232,428,272
Miners employed	594,768	833,629
Number of tons per miner	593	279
Average number of days	202	262
Average daily tonnage per miner ...	2·93	1·07
Number of miners killed	1,996	1,034
Death-rate per 1,000 men	3·35	1·24
Death-rate per 1,000,000 tons	5·66	4·44

* *Mines and Minerals*, 1907, vol. xxvii., page 261.

The striking feature of this table is first, the greater number of tons produced in America per miner; and secondly, the much higher death-rate per 1,000 men employed. This increased death-rate may be due in part to the increased rate of production, but it is not wholly so, and it is interesting to note from the report, for 1906, of Mr. James E. Roderick, Chief of the Department of Mines of Pennsylvania, that, as regards mines inspection, the British mines are not subject to so much inspection as the American mines.

The following table, taken from the report, is of interest for comparison*:—

	Number of Inspectors.	Number of Mines in charge of each Inspector.	Number of employees inside of Mines in charge of each Inspector.	Production, in tons, for each Inspector.
Great Britain	38	*103	18,642	6,663,870
Pennsylvania, bituminous district	20	69	7,093	6,476,649
Pennsylvania, anthracite district	20	32	5,818	3,511,028

* In addition to these mines the inspectors have charge of all quarries.

The report of the chief inspector seems to show that the addition to the number of inspectors has not reduced the number of accidents, for, to quote his words:—"It will be necessary, therefore, to resort to some other method to bring about this greatly desired result."†

In the writer's opinion, the mining of coal is to some extent hereditary, and when it is considered that in America the output of coal was 22 tons in 1814, while in this country, at the same period, the output was upwards of 15 million tons, it will be seen that we had had a very considerable start. The increased output per miner in the United States is no doubt due to the greater average thickness of the seams, and to the easier accessibility of the coal. In some of the anthracite mines the working of the coal is more analogous to quarrying than to mining as practised in this country. In the anthracite district of Pennsylvania, out of 563 mines 355 are slope or drift mines; and in the bituminous district of Pennsylvania, out of 1,232 mines 1,070 are slope or drift mines.

* *Report of the Department of Mines of Pennsylvania*, 1906, part i., page 22.

† *Ibid.*, page 21.

Chemical Mine Fire-engine.—At the mines of the Pine Hill Coal Company, Minnesville, Pennsylvania, a chemical fire-engine (fig. 1) has been installed. The engine consists of two 60-gallon steel tanks, which are filled with a solution of soda consisting of 24 pounds dissolved in 60 gallons of water. Within the tank is a receptacle containing 12 pounds of 66-degree sulphuric acid; the chemicals being kept apart until it is desired to use the engine. When the engine is in use, the sulphuric acid is mixed with the alkaline water, causing carbon dioxide to be generated rapidly. With this engine a fire of considerable proportion can be successfully dealt with, and similar engines have been adopted at several of the large collieries.

Fig. 1.—Chemical Mine Fire-engine.

Supporting Excavations by Concrete.—At the Burnside colliery of the Philadelphia and Reading Coal and Iron Company, Pennsylvania, concrete arches for the support of main roads in place of timber are in use. Arches, some 18 inches square, were used to replace timber sets, 14 to 16 inches square. The design of the arches is shown in fig. 2, and the cost varied from £4 10s. to £5 10s. per arch. These arches have successfully carried the weight, which previously caused continual breakage of the

Fig. 2.—Concrete Arching at Burnside Colliery, Pennsylvania.

timbers. There are, no doubt, cases where an extended use of concrete would be desirable for the support of excavations in English mines.

Power-stations, etc.—Montreal is being supplied with electric power from the Shawenegan Falls, which are situated on the St. Maurice river, halfway between Montreal and Quebec. The total height of the falls from the upper to the lower lake is about 140 feet, and the total available power is estimated at about 100,000 horsepower.

In designing the power-station, the chief question was whether the turbines should have a vertical or a horizontal shaft. At Niagara, as will be seen later, the turbines are placed vertically, but here the horizontal type is adopted, it being considered that it is, mechanically, more reliable. It was also decided to have a slow speed, and so the generators revolve at 180 revolutions per minute, and the current is produced at 2,200 volts. There are at present three units installed, each wheel being capable of developing 6,000 horsepower, and these are coupled to generators of the revolving-field type of 3,750 kilowatts capacity, the current being two-phase and 2,200 volts. Another unit of 10,000 horsepower is now being installed.

The transmission to Montreal is interesting; the current is transformed at the generating station up to 50,000 volts for the long distance users. The length of the line to Montreal is 85 miles, and the cables are of aluminium, the total drop in the transmission when 8,000 horsepower is being delivered in Montreal being 18 per cent. of the delivered voltage.

The use of aluminium is general for high-voltage lines. The production of this material has so rapidly increased that, although its resistance is 2·6, that of copper being 1·5, with aluminium at present prices it is the cheapest for overhead and uninsulated lines. The greater area required, however, prohibits its use for insulated cables.

Brief mention may be made of the electric power-stations at Niagara. On the American side, there are being generated by the Niagara Falls Power Company, and others, 150,000 horsepower; while developments are now in hand to give an additional 100,000 horsepower. On the Canadian side of the falls, the development is in active progress, which, when completed, will

amount to more than 400,000 horsepower, and the grand total of power then derived from the Niagara river will be about 700,000 horsepower, two-thirds of which are on the Canadian side.

The "harnessing" of Niagara seems now like ancient history; but it was only as recently as 1890 that the International Commission (of which Prof. W. C. Unwin and Lord Kelvin were members) was selected for the purpose of advising as to the best means of converting the power of the falls into electrical energy. As has already been stated, this pioneer power-station is the only one on the American side of the falls. The station has an output of 75,000 electrical horsepower. The method adopted is to tap the Niagara river above the falls by a short canal, and then to excavate a wheel pit, at the bottom of which the turbines are placed, the generators being on the surface and connected to the turbines by hollow shafts.

In the two power-houses are placed twenty-one units, each of 5,000 horsepower. The wheel pits are about 450 feet long, 18 feet wide and 180 feet deep. The current is generated, as at Shawenegan falls, at 2,200 volts, and is stepped up as required for transmission.

Three new undertakings are progressing on the Canadian side, but it is a pity to note that the capital for two of these is largely American. The designs for two of the plants are similar to those of the Niagara Falls Power Company, *i.e.*, vertical turbines. The units of these newer stations are all about 12,000 horsepower.

The works of the Ontario Development Company, which the writer visited, were in a very interesting stage. The wheel pit at the time was in course of excavation; but before any work could be done on sinking it, the coffer dam, 2,200 feet long and extending about 600 feet into the river, had to be constructed. This dam laid bare 11 acres of the river bed, its building being a most difficult undertaking; and it is creditable to the engineers that it was accompanied with the loss of only one life. The wheel pit, which is 416 feet long, 27 feet wide, and 150 feet deep, will be lined with brickwork. At the bottom of the wheel pit will be placed eleven turbines, each of a capacity of 12,500 horsepower. They are connected with generators by means of hollow steel shafting. The generators are to be of 8,000 kilowatt capacity, revolving at 250 revolutions, and delivering a three-phase current at 12,000 volts. About 1,500 feet from the generat-

ing station, the transformer house is being erected to raise the voltage to 40,000, 50,000, or 60,000 volts for transmission to the points required.

The only other feature that the writer wishes to mention is with regard to the power companies at Niagara, and that is in connection with the works of the Ontario Power Company, who are conducting the water from above the rapids by means of three main conduits, 18 feet in diameter and 6,000 feet long, buried in the ground. All the other companies have canals. and the utilization of these steel pipes, ½ inch thick, will be watched with interest. Although in the modern designs every effort is being made to preserve the natural beauties of the falls, it is inevitable that these should suffer.

Of course, it must be borne in mind that in laying out the works for harnessing Niagara, the tunnel tail-race, feeder-canal, sluice-gates, etc., had first to be constructed up to the full ultimate capacity of the station, although only a small fraction of that amount of power could at first be utilized; consequently, it will require several years for the undertaking to grow to maturity, and, during this time, a large portion of the capital expended on the works must lie idle.

With the large power-stations in this country, however, a system of multiple units can be adopted and the plant worked under conditions of much higher initial efficiency. In almost every power-station one finds provision made for extension; the engine-house wall at one end, for instance, will be of a temporary character, so as to permit of readily extending the building and rendering the whole plant convenient for supervision, distribution, etc.

By far the greater percentage of our power in this country is, of course, obtained from the use of coal generating steam in boilers of various types, and used either in reciprocating engines or rotary turbines, and there is no doubt that a cheap coal supply is worth far more to us than would be water-power without it.

The growing use, however, of small coal for the manufacture of coke and its use in producers where ammonia, etc., is recovered, is tending to make the demand for small coal more extensive, and its price will tend to increase. Yet there is no doubt that, in many mines, particularly those in South Wales, a considerable quantity of small coal is left in the mine.

However much coal we may have, that is no reason why we should be prodigal in its use; and the writer regards the establishment of these large centres for power generation and distribution as of great economic value in the saving and conserving of our coal resources.

Time was, and to some extent still is, when by the multiplication of small power plants, not burning the coal economically, thousands of tons of coal were wasted per annum and without any useful result; but the old notion is now, the writer thinks, exploded, that because coal is cheap we can afford to waste it. In small plants that are not employed for much of their time, we not only have the losses in wasteful consumption of fuel and wasteful use of steam, but also the additional loss of interest on the money sunk in the plant which, for the greater part of its time, is idle.

If we take the extreme example of a generating station for electric lighting only, we might get a load factor of 13½ per cent., representing 1,185 working hours at full load in the year, averaging about 3¼ hours per day. It is, of course, evident that, if we could increase the load factor, we increase the earning capacity of the plant without any addition to the capital and establishment charges. A power-station supplying several customers with varying demands can utilize a certain dovetailing which exists; for instance, arrangements can be made with a colliery customer to take power for pumping at certain hours of the day when there is not a heavy lighting load on.

It is, therefore, possible for a power-station of comparatively small capacity to supply customers with a much greater total demand. The total motors, etc., coupled up to a station might be 30,000 horsepower, but the demand might never be more than, say, 15,000 horsepower at one time.

The electric transmission of power is certainly a branch of engineering in this country which, as the coal supply becomes exhausted, must be considered more and more, and the writer ventures to think that a study of American practice will be of advantage in this particular.

Street Railways.—One great question that struck the writer with regard to the street traffic in New York and other American cities will be of interest: that traffic may be divided into three sections, (1) surface, (2) elevated, and (3) shallow subways.

The Rapid Transit Company, who have constructed the subways in New York, have, therefore, been under the wing of the Corporation instead of (as so often happens in this country) having to fight them, and to this is due the methods employed in construction, which, to an Englishman, would appear impossible, involving as they did such interruption with the street traffic. The contracting company has, the writer understands, a lease of 45 years, after which the city will become the owners. The expenditure on the new rapid transit railway was estimated to be £10,000,000. The line is 25 miles long; construction was begun in 1900, and the line was opened at the end of October, 1904.

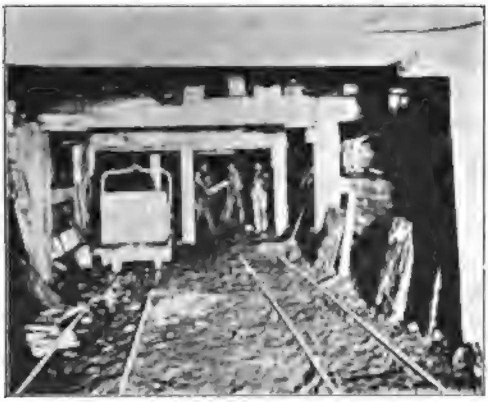

Fig. 3.—New York Subway: Excavation and Timbering at Broadway and Fulton Street.

The railway is not altogether underground: in some places viaducts have been built; but for the greater portion of its length the subway is at a small depth below the road level. For about half the length, the roads were opened during construction, the principal being that of "cut and cover." In New York the ground is practically rock throughout, and high buildings may be seen standing alongside the excavations with very little underpinning.

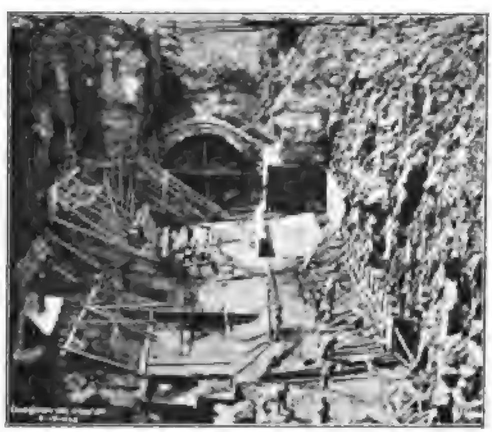

Fig. 4.—New York Subway: Excavation for Station at Mott Avenue.

Such a concession must have greatly cheapened the cost of the work of the company, but the inhabitants along the route must have suffered some disadvantage. In the busiest parts of the route, however, in the case of the deeper railways, tunnels were driven and timbered (figs. 3 and 4), similar to driving a road in a mine.

The question of foundations for the skyscrapers on route has been a very difficult one, although simplified by the rock substrata, but it has been admirably surmounted. The steel structures of these buildings enabled them to be supported by carrying columns through the basement and subway.

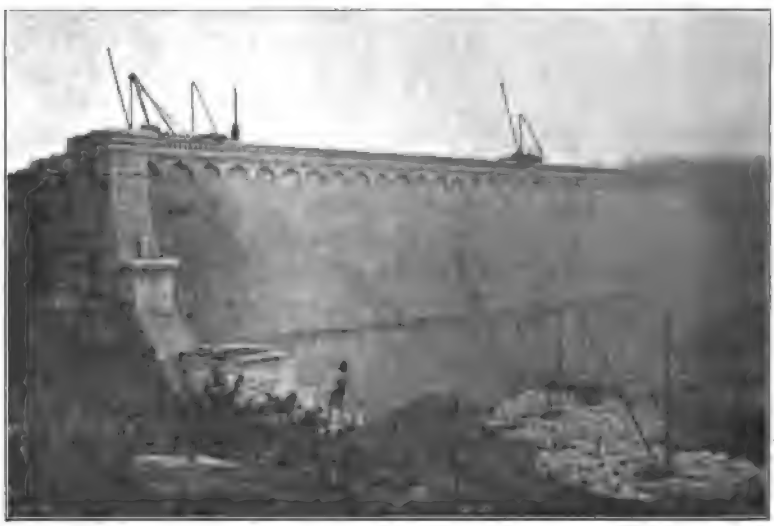

Fig. 5.—New York Water Supply: Croton Dam.

There are about fifty-two stations in all, and it is refreshing to learn that no advertizements are to be allowed, so as to give the passenger at least a chance of finding out the name of the station before the train again starts. During the two hours when traffic is heaviest, the express trains will be able to carry 72,000 persons, and the local trains 90,000 per hour. The express trains are accommodated with a separate track over a large portion of the route.

The generating station, it is claimed, will be capable of producing more electrical power than any other in the world, and when fully equipped will have cost £1,400,000.

The power-house is 200 feet wide and 700 feet long. At present there are nine engines of 8,000 to 10,000 horsepower,

which are directly connected to 5,000-kilowatt alternators, generating energy at 11,000 volts. The total capacity of the complete station can safely be placed at 130,000 horsepower. The engines are reciprocating, and the only use of the turbines is for driving the lighting dynamos. This is possibly explained by the fact that at the time when the generating station was designed, turbines had not reached so high a state of perfection as that in which we now find them.

FIG. 6.—NEW YORK WATER SUPPLY: CROTON DAM, SPILLWAY.

It is interesting to note that the entire plant is designed on a unit system. Each section consists of a chimney, twelve boilers, and two engines. Each section can be disconnected from the general system by power-operated valves. Another interesting feature is, as regards the rolling stock, the admirable arrangements for safety; no sooner does the engine-driver release his hand from the lever than the brakes commence to act. The whole scheme is an admirable tribute to the capability and daring of the American engineer, who, by skill, pluck, and determination, has successfully solved this important problem.

New York Water-supply.—The water-supply of New York, a rapidly growing city, needs constant extensions in order to cope with the demand. The dam shown in fig. 5 is intended to im-

pound an additional supply of something like 30,000,000,000 gallons of water. The total height from the bottom of the footings to the top of the parapet is 297 feet, with a thickness at the bottom of 206 feet, and a thickness at the top of 18 feet.

Work on the Croton dam has been in progress for about twelve years, and it is expected to be finished very shortly. The total length of the dam is 1,168 feet, the total volume of masonry being 750,000 cubic yards. An interesting feature of the construction was the fact that considerable delay was experienced by the derricks on the top of the wall constantly having to be removed as the masonry grew up around them. This difficulty was overcome by building two steel towers, on which the derricks were placed, at a considerable height above the work. As the dam rises in height, the lower portions of the towers are enclosed and permanently built in. Fig. 6 shows the spillway of the dam.

Fig. 7.—View of Portion of Cripple Creek.

Cripple Creek Gold District (fig. 7).—Statistics are usually dry reading, but the record of this wonderful district is so remarkable that a few figures will prove interesting. Gold was first discovered here in paying quantities in 1891; within a decade it had become one of the greatest gold-producing regions of the world. In rapid development and in the richness of its ores, nothing like it has ever been known before. In ten years the cattle ranches had been transformed into a populous district of 60,000 people. The production to that date approximated £24,000,000, whilst, in 1901, it exceeded £5,000,000.

Summary.—The writer has now very rapidly presented for the consideration of the members the most important notes of his visit to America and Canada, and it only remains for him, in a

very few words, to summarize the points which impressed him most during his visit.

(1) With regard to America, his observations brought him to the conclusion that those two industries in which we are most interested, namely, coal and iron, are, without doubt, the most advanced and perfect as regards their development and arrangement. With reference to the iron trade, and the making of steel, he was particularly struck with the immense use of labour-saving appliances, which explained to him the fact that for what labour they required American factory owners and works managers were enabled to pay a high rate of wages. The development of coal in America has been distinguished by the fact that it is produced in huge quantities, and worked at shallow depths, and at comparatively moderate cost, until recently, when large requirements for coal rendered sinking to greater depths necessary.

There is one economic fact, the end of which it is difficult to forecast, that to a great extent the coal-fields are in the hands of a very limited number of people. The Pittsburg Coal Company and the Carnegie Trust each hold between 150,000 and 200,000 acres with all the underlying seams of coal of great number and thickness, and what has to be taken into consideration is the fact that such national wealth, which can never be replaced, is in the hands of so few. It is, therefore, in such articles as coal and ironstone that the trusts command the position for controlling their production, whilst other trades have not the same means of holding their position in a monopoly.

With reference to electrical power, there can be no doubt whatever that it is more extensively used, and is much more highly developed and cheaper than in England, being in almost universal application in commercial, industrial, and private life.

(2) As regards Canada, the writer was much impressed with its prosperity as a colony and the great future before it in its agricultural and even mineral wealth, the climate being, taking it altogether, a very pleasant one.

(3) With regard to education, the writer was most favourably impressed with the fact of America having realized and responded to the necessity of educating engineers to construct and carry out their works by a thoroughly scientific training at its universities, where they acquire that theoretical knowledge which they utilize later in the practice of engineering. As a

rule, with few exceptions, the present American civil and mining engineers of eminence, and the younger men coming on, are all graduates in engineering at one or other of the universities, on which solid foundation is produced the desirable combination of the scientifically trained and thoroughly practical engineer, so beginning on a system in a new country which the old country has only just realized the necessity of; and it is to this, associated with its vast natural mineral resources, that the prosperity of America is due.

Mr. A. L. Steavenson (Durham) said the paper was a very comprehensive one, and it raised so many points, ranging from shot-firing to the falls of Niagara, that he thought the discussion should be adjourned until the members had had time to consider it. On the subject of shot-firing, it must be borne in mind that there was not only the question of a man seeing gas and understanding what it was, but the personal element came in very strongly, and the question was what the man would do if he did see gas; would he have sufficient common-sense to know what to do, and would he be capable of doing it, apart from the fact that he recognized gas when he saw it? He moved a vote of thanks to the writer of the paper.

Mr. J. G. Weeks (Bedlington) seconded the vote of thanks, and at the same time intimated that he did not agree with the writer's remarks as to the necessity for certificates for shot-firers or deputies. He thought that mining engineers in this country knew their business quite as well as those in America, and, if they were to be judged by the results as revealed in the paper with regard to safety, were even a long way ahead of them. He thought that such certificates were totally unnecessary, so far as the class of men were concerned for whom they were recommended. The certificated manager of a colliery was pre-eminently much better fitted to select suitable persons than any board of examiners, however talented or selected. So far as regarded safety of life, he did not think that their brethren in America had anything to teach them as yet.

Mr. J. B. Atkinson (H.M. Inspector of Mines) said that he was rather surprised to hear the figures as to the quantity of coal

raised in America. It was only a few years ago that the output of America had reached the total of this country. If the author's figures were correct, the advance must have been very rapid.

Mr. WALTER ROWLEY said that it had been very rapid, but, if the figures were not right, he would be glad to be corrected; so far as he knew, however, they were so. Referring to Mr. J. G. Weeks' remarks, it was really with the intention of raising this question of certificating that the writer had offered his paper to the Institute. In his opinion, the fact of certificating officials raised the standard of the men, certainly as regards education, and doubtless many opinions would be given on this point when the final discussion on the paper took place.

Prof. HENRY LOUIS (Newcastle-upon-Tyne) said that although he believed the statistics quoted to be correct, yet, large as the output of coal was, coal-mining in America was of secondary importance compared with metal-mining.* Any complete review of American mining matters must take cognizance of the enormous output of copper, and also of the huge output of lead, zinc, etc., not to mention the precious metals. There was a great deal to be said on many of the points raised in the paper, but it would take too long to go into them at that meeting.

The PRESIDENT (Mr. John H. Merivale), in putting the vote of thanks to the meeting, referred to the question of boy-labour. The author had pointed out that in America, according to law, 16 years was the age at which lads could go down the pit; but from accounts, recently published in the papers, one poor little fellow, who was only 11 years of age, suffered in a terrible accident the other day. He thought that this showed the mistake which was made in trying to legislate beyond the consciences of the persons for whom they were legislating.

The vote of thanks was cordially adopted.

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* Since speaking, he had received the official statistics for 1906, which gave the output of bituminous coal for that year as 381,162,115 short tons (of 2,000 pounds) and of anthracite as 131,917,694 long tons (of 2,240 pounds). It was difficult to compare these figures with the total mineral production, because the output of metals as reduced from the ores was given, but it might be said that the total value of all the minerals and metals was given at 1,902½ millions of dollars (380½ million pounds sterling), out of which the value of the coals was given as 513 millions (nearly 53 million pounds sterling).

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN THE HALL OF THE INSTITUTE, HAMILTON, DECEMBER 12TH, 1907.

DR. ROBERT THOMAS MOORE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of the Special Meeting of the same date were read and confirmed.

THE LATE MR. M. WALTON BROWN.

The PRESIDENT (Dr. R. T. Moore) referred in sympathetic terms to the death of Mr. M. Walton Brown, Secretary of The Institution of Mining Engineers, and intimated that the Council had instructed the Secretary to draw up a minute of condolence and that the following minute had been sent to Mrs. Walton Brown:—

The Council agreed to place on record their sense of the loss sustained by the Institute through the death of Mr. M. Walton Brown, which took place suddenly on November 22nd.

Mr. Brown was a member of the Institute and Secretary of The Institution of Mining Engineers. Since 1893, when the Institute was federated with The Institution of Mining Engineers, the members had had abundant opportunity of observing with what diligence and care he carried out the difficult and often trying duties entrusted to him: and there was no doubt that the present flourishing condition of The Institution of Mining Engineers was largely due to his earnest labours in its interest.

The members of Council for themselves, and on behalf of the Institute, gave expression to their deep sympathy with Mrs. Brown and her family in their sudden bereavement, and instructed the Secretary to communicate a copy of this minute to Mrs. Brown.

The following gentlemen were elected:—

MEMBERS—

Mr. JOHN WESLEY HECKELS, Buckhill Colliery, Great Broughton, Cockermouth.

Mr. MORTON WEBBER, Junior Conservative Club, Glasgow.

STUDENT—

Mr. ALEXANDER ROBERTSON, The Thorns, Uphall.

Mr. THOMAS TRAIN CHRISTIE read the following paper on "A Wagon-lowering Device for use at Colliery Screens":—

A WAGON-LOWERING DEVICE FOR USE AT COLLIERY SCREENS.

By THOMAS TRAIN CHRISTIE.

The apparatus consists of two brake-beams, or girders, *a* (figs. 1, 2 and 3), laid parallel to, and between, the rails, *b*, each brake-beam being pivoted to a special sleeper at the back end. These brakes act on the inner sides of the wheel, *c*, being pressed outwards against them. They are operated by means of a hand-wheel, *d* (fig. 3), fixed to the end of a vertical shaft, *e*, and placed in a position convenient to the wagon-trimmer at the level of the coal-belt. At the lower end of the vertical shaft is a worm,

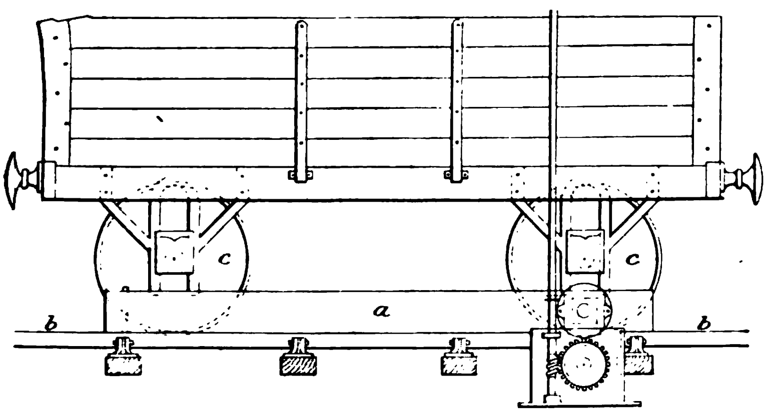

FIG. 1.—SIDE-ELEVATION, SHOWING WAGON IN POSITION READY FOR LOADING.

f, which gears with a worm-wheel, *g*, fixed on a horizontal shaft, *h*, running underneath the rails. On this shaft is a spur-wheel, or sprocket-wheel, *i*, which gears with another spur-wheel, or sprocket-wheel, *j*, on a second parallel shaft, *k*, which has its ends formed with right- and left-handed threads, *l*, working into nuts fixed to the ends of the brake-beams.

By a very slight movement of the hand-wheel, *d* (fig. 3), both side-brakes, *a*, are simultaneously applied, or released. In order to provide a wearing surface, the brake-beams are, in practice,

faced with hard-wood planks, which form an inexpensive facing, and are easily renewable.

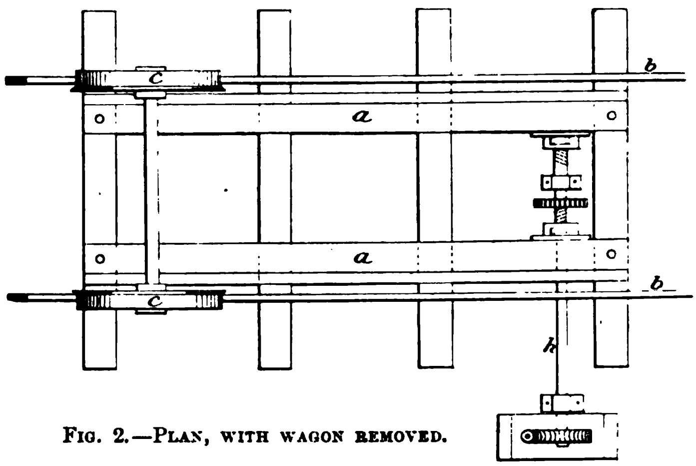

FIG. 2.—PLAN, WITH WAGON REMOVED.

The brake is a very powerful one, and in practice the controller is found capable of holding, with absolute safety, a train of six wagons, coupled together, on a gradient of 1 in 70.

The empty wagons are brought under the screens in trains of four wagons, coupled together, and these are loaded and trimmed without the trimmer requiring to leave the scaffold. The second train of empty wagons is run into position in time to allow of continuous loading.

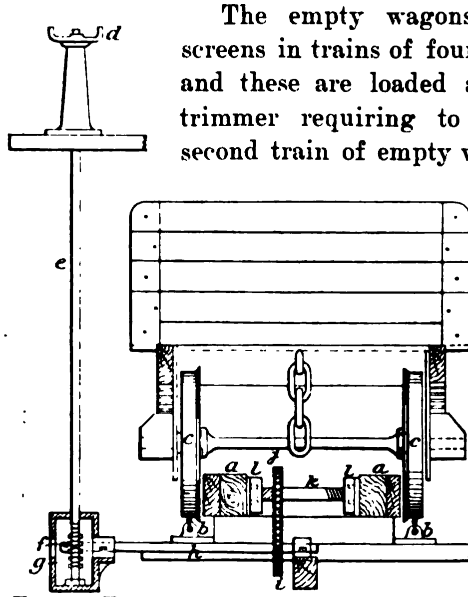

FIG. 3.—END-VIEW, SHOWING WORKING PARTS.

At a colliery where this apparatus is in use, producing an average daily output of between 1,100 and 1,200 tons, there are in all seven coal roads, three large coal roads and four small. Prior to the introduction of the controller, nine men were employed in trimming wagons, bringing in empties, removing the loads, and cleaning the roads. These were distributed as

follows:—On the large coal roads four men were employed: two trimming, one moving wagons and cleaning the roads, and one bringing in empties and removing the loads. On the small coal roads, five men were similarly employed. At present one man is sufficient to attend to the three large coal roads, trim the wagons, and clean the roads, and two men attend to the small coal roads and bring down the empty wagons.

This represents a saving in the wages bill of over £8 per week, and the company's liability risk is proportionately reduced. Other advantages experienced from the introduction of the controllers are (1) a saving in cost of material due to the reduction in use of hard-wood scotches; (2) a considerable reduction in the breakage of coal; (3) greater uniformity in the loading of the wagons; and (4) a freedom from coal falling over the sides of the wagons. All these advantages follow from the fact that, in loading, the wagon is moved forward a few inches at a time.

The President (Dr. R. T. Moore) said that the subject of the paper appealed very strongly to them. They all had wagons that required to be controlled at the screens, and the present practice adopted at so many collieries—that of trigs—seemed to be rather barbarous. It certainly was a great advantage and benefit to have the wagon under the control of the screenman. The model exhibited by Mr. Christie appeared to show that the device was an effective one. Personally, he thought that he had seen it in operation at one of the English collieries which they had visited in connection with their excursions some years ago. So far as he was able to make out, it worked very effectively there.

Mr. J. M. Ronaldson (Glasgow) said that he had examined the model of this appliance, and it appeared to be an admirable device for the purpose. They all knew of the dangerous occupation of the screenman, especially at their more modern collieries: there was so much noise, that a man was practically deprived of the use of his ears, and had to trust to his eyes to guard against approaching danger. He thought that any device that prevented men from going down on to the rail at the screens was worthy of consideration. So far as he could judge from the model, this seemed a very simple, easily-applied, and effective device. Speaking for himself, he would be very pleased to see it in vogue at

their collieries. He was satisfied that if they had such an appliance there, it would be the means of saving a good many lives throughout the kingdom in the course of the year. They would all remember the device brought before them some years ago by Mr. Miller. That arrangement did not seem to have been adopted at collieries. He did not quite know why; but, on comparison of the two devices, the method of controlling the wagon by letting it go a few inches at a time appeared to be a better one than that aodpted by Mr. Miller.

Mr. J. T. Forgie (Bothwell) said that the arrangement seemed to be a sensible way of getting over the difficulty of shifting wagons. Frankly, he did not place so much stress on the economy of the device. He could hardly see from the figures that Mr. Christie had given that it would be so economical as he (Mr. Christie) supposed. In the number of roads that the author had stated there ought not to be so many men required in shifting wagons. Mr. Ronaldson had referred to the modern colliery erections, but he did not know whether perhaps, after all, these were not safer than the old erections, so far, of course, as the shifters and cleaners were concerned. In connection with the old erections there used to be posts between the lines of rails. Now, to a great extent, these posts had been done away with, and thus the spaces between the rails were far clearer and generally wider than they used to be. The tendency, of course, of that had been to save life and prevent accident. So far as his (the speaker's) experience went, accidents had not been numerous with the screens. In his own firm's collieries they had very few accidents at the screens. Anything, however, that simplified the old method of shifting these wagons ought to be adopted, if possible. The only question appeared to be in regard to the capability of the device to take more than six wagons at a time. Sometimes it was inconvenient to have a small number of wagons, as that meant more labour in bringing the wagons forward to the screens. At the collieries with which he was connected, he knew that they sometimes had twelve, fifteen and eighteen wagons against the trigs. The device, in his opinion, was an excellent one, and ought to be seriously considered by those who had a large number of wagons to shift at their collieries.

Mr. Robert M'Laren (Edinburgh) said that, notwithstanding

all the progress made in mining engineering in recent years, it was passing strange that the dangerous method of trigging wagons was still in operation. Anything therefore that could be done to abolish the old and out-of-date system of the trigs ought to be commended. The device under discussion seemed a very good one, but the question arose: could this arrangement be applied to the collieries as they were fitted at present? Would too much room not be required between the sets of rails? If there was room, he thought it would be well for the owners to adopt some such system. It was a lamentable fact that so many accidents were occurring at the screens, due to trigging. The wagons nowadays, too, were more cumbersome and more difficult to handle, being larger. It would, he thought, be an advantage in favour of the arrangement described if it could be made automatic. He did not, however, see that there could be much economy with it, because at each set of rails there must be a man in control.

Mr. J. M. Ronaldson (Glasgow) said that, by way of supplementing the remarks of Mr. Forgie, he should like to say that he was afraid that even yet there were far too many posts in existence between the lines of rails. He knew that at the collieries in process of erection, or recently erected, the tendency assuredly was to do away with these posts, and to have girders right across. Unfortunately, even yet men got crushed between them and the wagons.

Mr. Thomas Turner (Kilmarnock) said that perhaps Mr. Christie could tell them why the device had been limited to six wagons.

Mr. T. Train Christie said that, as a matter of fact, at the colliery where he had seen the apparatus in operation the sidings were so designed that four wagons were all that could be accommodated at a time. They coupled four wagons, loaded four, and then removed them. Of course, there might be a considerable weight of empty wagons on behind. He understood that the apparatus was so designed that ten loaded wagons could be successfully operated by it. In his paper, he had modified the capabilities of the device to six loaded wagons, because he did not want to put the capabilities of the device higher than he was justified in doing. There was no reason why they should not have a con-

siderable load of empty wagons on behind, provided that they removed the loaded requisite number of wagons.

Mr. Thomas Turner (Kilmarnock) asked Mr. Christie whether he considered six the limit to the number of loaded wagons that could be taken.

Mr. T. Train Christie said that he understood that ten was the limit of loaded wagons that had been decided upon.

Mr. Thomas Thomson (Hamilton) said that there was nothing to prevent ten, twelve or twenty wagons, all of them empties, to be behind the loaded ones. As he understood it, they did not require to bind themselves down to four or even six loaded wagons. Whenever a wagon was finished and loaded, they had merely to let it away. He did not think that there was so much economy in the apparatus as Mr. Christie had made out. He knew from experience that there must be a trimmer and a shifter in attendance. At some of the collieries with which he was connected, if the trimmer was not continually working something was sure to go wrong.

Mr. T. Train Christie said that the economy effected resulted from the fact that by this system they had only one trimmer for three tables instead of having one trimmer at each table. Not only this, but there was a saving in the cost required to clean up the roads; and there was, further, a great saving in the breakage of coal. With regard to the question put as to whether the device was applicable to modern collieries, he would point out that there was one feature which had struck him as being adverse, and this was that at some of their collieries the gradients were not such as to warrant the introduction of the device. He was certainly inclined to think that if these controllers were adopted at collieries, and the sidings banked up so as to allow of easy running gradients, a considerable advantage would accrue.

The President (Dr. R. T. Moore) said that they felt greatly indebted to Mr. Christie for bringing his paper before them. It was papers of this sort (describing matters which came under their observation every day) which were of great value to the Institute. The members benefited considerably from the discussion on such communications. Their thanks were certainly due to Mr. Christie for his paper.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

ANNUAL GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
OCTOBER 8TH, 1907.

MR. HENRY BRAMALL, VICE-PRESIDENT, IN THE CHAIR.

FOGGS COLLIERY DISASTER.

MR. JOHN ASHWORTH moved a vote of deep sympathy with the relatives of the ten men who had been killed, and with Mr. Henry Bramall and Messrs. Andrew Knowles & Sons, Limited, in the disastrous shaft accident which had occurred at Foggs colliery on October 4th.

The motion was carried.

MR. HENRY BRAMALL said that he greatly appreciated the members' expression of sympathy.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. MALCOLM BURR, Mining Engineer, Sibertswold, near Dover.

Mr. WILLIAM SHERMAN TOPLIS, Electrical Engineer, Novara, Rowan Avenue, Higher Brooklands, near Manchester.

Mr. JOHN T. JONES, Colliery Manager, Foggs House, Little Lever, near Manchester.

The Treasurer's Annual Statement of Accounts was read as annexed.

DR. **THE TREASURER IN ACCOUNT WITH THE MANCHESTER GEOLOGICAL AND MINING SOCIETY, FOR THE YEAR ENDING SEPTEMBER 30TH, 1907.** CR.

	£ s. d.	£ s. d.	£ s. d.
Sept. 29th, 1906.			
To balance in bank			89 13 4
,, ,, in Secretary's hands			3 16 2
Sept. 30th, 1907.			
To members' subscriptions:—			
Arrears		15 8 0	
Current:			
Members	368 12 0		
Associate members	18 18 0		
Associates ...	6 5 0		
Students	8 15 0		
Non-federated members ...	38 0 0		
Subscribers ...	2 0 0		
		442 10 0	
In advance		8 4 1	
			466 2 1
To dividends:—			
Birkenhead Railway		22 16 0	
Lancashire and Yorkshire Railway		20 17 10	
			43 13 10
To Bank-interest, less commission			2 16 10
,, hire of rooms			5 2 6
,, sales of *Transactions*			8 17 11
			£620 2 8

	£ s. d.
Sept. 30th, 1907.	
By rent, wages, and expenses of rooms	159 2 4
,, printing and stationery	21 15 6
,, Catalogue of library, and books purchased ...	50 8 11
,, postages, etc.	25 5 9
,, reporters	10 10 0
,, furniture	6 17 3
,, sundry expenses, insurance, etc.	4 6 7
,, The Institution of Mining Engineers	250 12 3
,, printing *Transactions*	15 16 0
,, expenses of meetings	6 11 3
,, Honorary Secretary's expenses	9 0 0
,, balance in bank	51 10 11
,, ,, in Secretary's hands...	8 5 11
	£620 2 8

Library Fund.

Dr.	£ s. d.		Cr.	£ s. d.
Sept. 30th, 1907. To library expenditure	1 13 9		Sept. 30th, 1906. By balance	1 13 9

Balance Sheet, September 30th, 1907.

Liabilities.	£ s. d.		Assets.	£ s. d.
Outstanding accounts, say	58 10 3		Investments:—	
Balance in favour of the Society	1,850 1 1		£600 Birkenhead Railway 4 per cent. Consolidated Preference Guaranteed Stock, at £114	684 0 0
			£733 Lancashire and Yorkshire Railway 3 per cent. Consolidated Preference Stock, at £82½	604 14 6
			Library and furniture	500 0 0
			Cash in bank	51 10 11
			,, in Secretary's hands	8 5 11
			Arrears of subscription (estimated value)	60 0 0
	£1,908 11 4			£1,908 11 4

The assets of the Society, as shown by the balance-sheet, are £134 11s. 3d. less than at September 29th, 1906: £53 5s. 6d. of this diminution is accounted for by the shrinkage in the market value of the Society's investments in railway stocks, and the balance is almost entirely due to the expenses incurred upon Library accounts: by the binding of many volumes, the purchase of new books, and the preparation of the Catalogue, which has just been printed and issued.

Geo. H. Hollingworth, *Honorary Treasurer.*

The Investments of the Society consist of £600 Birkenhead Railway 4 per cent. Consolidated Preference Guaranteed Stock, and £733 Lancashire and Yorkshire Railway 3 per cent. Consolidated Preference Stock. The certificates for these are deposited at Messrs. Williams Deacon's Bank, Limited, St. Ann's Street, Manchester, and were inspected by us on October 8th, 1907.

Audited and found correct, October 8th, 1907.

Jon. Barnes,
G. H. Winstanley, } *Honorary Auditors.*

The HONORARY SECRETARY (Mr. Sydney A. Smith) read the Annual Report of the Council as follows:—

ANNUAL REPORT OF THE COUNCIL, 1906-1907.

The Council have pleasure in submitting the sixty-ninth Annual Report on the work and progress of the Society during the past year.

Twenty-four new members have been elected during the year, of which 16 are federated members, 4 federated associate members, 2 federated associates, 1 federated student, and 1 non-federated member. Two students have been transferred to the federated members' list. The resignations during the year have been 9 federated members and 5 non-federated members; while, in addition, the names of several members whose subscriptions to the Society were considerably in arrear, have been removed from the list.

The classification of the membership for the year 1906-1907 is shown in the following table:—

Classification.	Non-federated Members.	Federated Members.	Totals.
Honorary members	11	—	11
Members, inclusive of life members	53	197	250
Associate members	—	9	9
Associates	—	5	5
Students	—	10	10
Totals ...	64	221	285

It is with feelings of deep sorrow that your Council record the death of Mr. Mark Stirrup, who became a member in the year 1880, and in the year 1904 was elected an honorary member in recognition of his devoted service to the Society. Mr. Stirrup was President for the year 1896-1897, and for a number of years previously had held the office of Honorary Secretary. Other members whose deaths have to be recorded are Mr. Henry Jobling, elected in 1883; and Mr. Ronald Gordon Grant, elected in 1904.

During the session, nine ordinary meetings of the Society have been held, a special evening meeting, and an excursion-meeting, all of which have been well attended by the members. There have been twelve Council meetings. The special evening meeting was held at Victoria University on June 28th by the

kindness of the University authorities, and Prof. W. Boyd Dawkins exhibited a number of recent additions to the Museum-collection. At this meeting, short addresses were delivered on "The Coal-measures," "The Formation of Coal-balls in the Coal-measures," and "Carboniferous Flora as an Aid in Stratigraphical Classification," by Prof. W. Boyd Dawkins, Mr. D. M. S. Watson, and Mr. George Hickling respectively.

At the invitation of the President, Mr. Charles Pilkington, the members visited the Pilkington Tile and Pottery Works at Clifton Junction on June 19th. The excursion was attended by upwards of fifty members. The party was courteously conducted over the company's extensive works by Messrs. Burton, the managers, and their assistants. An enjoyable afternoon was spent in examining the methods of production of tiles, pottery, etc., in various stages, after which the members were hospitably entertained by the directors of the company.

Mr. Charles Pilkington in his Presidential Address discussed a number of present-day problems, including the practicability of coal-cutting by machinery, applied to the general run of collieries; the difficulties arising from the inevitable increase in the depth of pits; the methods to be adopted for the prevention of coal-dust explosions; and the various obstacles to be overcome in working coal under water-bearing strata.

The geological interest has been maintained by communications from Prof. W. Boyd Dawkins, Messrs. John Gerrard, George Hickling, W. A. Ritson, Mark Stirrup, F. J. Thompson, William Watts, and David Watson. The contributors of mining subjects include Messrs. W. H. Coleman, John Galliford, A. M. Henshaw, William McKay, Charles Pilkington, G. G. L. Preece, F. J. Thompson, and T. H. Wordsworth.

The list of papers and short communications, read before the Society during the session 1906-1907, is as follows:—

"The Cook Calorimetric Bomb," by Mr. W. H. Coleman.

"The Coal-measures," by Prof. W. Boyd Dawkins.

"A New Patent Reflector for Safety-lamps," by Mr. John Galliford.

"Demonstration of the Weg Apparatus," by Mr. W. E. Garforth.

"Horizontal and Vertical Sections of Coal-measures from Rishton, Lancashire, to Pontefract, Yorkshire," by Mr. John Gerrard.

"The Courrières Explosion," by Mr. A. M. Henshaw.

"Carboniferous Flora as an Aid in Stratigraphical Classification," by Mr. George Hickling.

"The Boultham Well at Lincoln," by Mr. William McKay.

"Presidential Address," by Mr. Charles Pilkington.

"Recent Improvements in the Design of Electric Cables for Collieries," by Mr. G. G. L. Preece.

"A Comparative Section correlating the Seams in the South and West Yorkshire Coal-fields," by Mr. W. A. Ritson.

"Demonstration of the Aerolith Rescue-apparatus," by Mr. Otto Simonis.

"The New and the Old Geology; and the New Ideas of Matter," by Mr. Mark Stirrup.

"The Rock-salt Deposits at Preesall, Fleetwood, and the Mining Operations Therein," by Mr. F. J. Thompson.

"The Formation of Coal-balls in the Coal-measures," by Mr. David M. S. Watson.

"Report of the Delegate to the Meeting of the British Association for the Advancement of Science, York, 1906," by Mr. William Watts.

"Cage-lowering Tables at New Moss Colliery," by Mr. T. H. Wordsworth.

The attention recently directed by the Royal Commission on Mines to the question of rescue-apparatus has resulted in a number of these appliances having been brought forward for discussion during the session, and members have had an opportunity of testing the merits of several types, including the Weg and the Aerolith.

The following papers, printed in the *Transactions* of The Institution of Mining Engineers, have been discussed at the meetings during the session 1906-1907, in addition to the discussion on papers contributed specially to this Society's *Transactions*.

"The Value of Fossil Mollusca in Coal-measure Stratigraphy," by Mr. John T. Stobbs.*

"The Courrières Explosion," by Messrs. W. N. Atkinson and A. M. Henshaw.†

"Rescue-apparatus and the Experience gained therewith at the Courrières Collieries by the German Rescue-party," by Mr. G. A. Mayer.‡

"A New Apparatus for Rescue-work in Mines," by Mr. W. E. Garforth.§

Resulting from the discussion on Mr. John T. Stobbs's paper on "The Value of Fossil Mollusca in Coal-measure Stratigraphy," a Mollusca Search Committee has been formed, and a number of valuable specimens (both marine and freshwater) have been placed by Mr. John Gerrard, the chairman of the committee, at the disposal of members interested. The Council commend this work to the consideration of members, believing that,

* *Trans. Inst. M. E.*, vol. xxx., page 443; and *Trans. M. G. M. S.*, vol. xxix., page 323.

† *Trans. Inst. M. E.*, vol. xxxii., page 439.

‡ *Ibid.*, vol. xxxi., page 575.

§ *Ibid.*, vol. xxxi., page 625.

if followed up, it will be of great assistance in the more definite correlation of the Coal-measures in this and other districts.

Two general meetings of The Institution of Mining Engineers have been held during the past year. The London meeting was held at the Geological Society's rooms, on June 13th and 14th, 1907, when the President, Mr. Maurice Deacon, delivered an important Address to the members.

A number of papers printed in the *Transactions* were discussed, and visits were made to the Park Royal generating-station of the Great Western Railway Company and the Knight, Bevan & Sturge cement-works, at Northfleet, of the Associated Portland Cement Manufacturers (1900), Limited.

The annual general meeting of The Institution of Mining Engineers was held at Sheffield, at the University, on September 4th, 1907.

The representatives of the Society on the Council of The Institution of Mining Engineers for the year 1907-1908 are:—Mr. John Ashworth, Mr. Charles Pilkington, Mr. Henry Bramall, Mr. John Gerrard, Col. George H. Hollingworth, and Mr. Sydney A. Smith (Honorary Secretary).

Mr. Charles Pilkington (President) and Mr. Henry Bramall were appointed by the Council as representatives of this Society, and gave valuable evidence before the Home Office Departmental Committee in reference to the proposed Miners' Eight Hours Bill.

Mr. Charles Pilkington and Mr. Sydney A. Smith have been invited to join the committee of the Mining Engineering Section by Mr. Maurice Deacon, the chairman, to represent this Society on the arrangements now being made in connection with the Franco-British Exhibition, to be held in London from May to September, 1908. Both gentlemen have accepted the appointment on behalf of the Society.

Prof. W. Boyd Dawkins was appointed to represent this Society at the centenary meeting of the Geological Society of London from September 26th to September 30th, 1907, and presented a congratulatory Address from the Society.

A new and enlarged edition of the Library Catalogue has been printed, and is available for the use of members. The expense of compilation and printing of this catalogue is considerable, and your Council hope that the benefit to members will be appreciated, and that a still greater use will be made of the valu-

able collection of books and general geological and mining literature, augmented during the year by several recent works on mining and mineralogy, together with a number of sections. Several new exchanges have been arranged, as a result of which the collection of serial publications will be made still more useful. The number of periodicals devoted to mining has also been increased.

The Honorary Treasurer's accounts show that the financial position of the Society continues in a satisfactory state, despite the considerable expenditure incurred in the compilation of the Library Catalogue, the binding of a large number of *Transactions* of the various Institutes for past years, and general improvements in the library. Eighty-six volumes have been bound during the year. In this respect, the disbursements of the current year may be regarded as covering several sessions, and the bank balance (now £51 10s. 11d.) may consequently be expected to assume a much larger total at the close of the year 1907-1908.

While thanking those members who have during the past session communicated papers and interesting articles at the meetings of the Society, your Council would again urge upon members the desirability of further supporting the Society's work by contributing papers which are likely to benefit the members, and by introducing eligible gentlemen to membership.

The CHAIRMAN (Mr. Henry Bramall) moved the adoption of the Council's annual report and accounts.

Mr. W. PICKSTONE seconded the resolution, which was approved and adopted.

ELECTION OF OFFICERS, 1907-1908.

The following officers were elected for the ensuing year:—

PRESIDENT:
Mr. JOHN ASHWORTH.

VICE-PRESIDENTS:

Mr. W. E. GARFORTH, M.Inst.C.E.
Mr. GEORGE B. HARRISON, H.M.I.M.
Mr. WILLIAM PICKSTONE.
Mr. T. H. WORDSWORTH.

HONORARY TREASURER: Mr. GEORGE H. HOLLINGWORTH, F.G.S.

HONORARY SECRETARY: Mr. SYDNEY A. SMITH, Assoc.M.Inst.C.E.

COUNCILLORS:

Mr. H. Stanley Atherton.	Mr. George H. Peace, M.Inst.C.E.
Mr. C. F. Bouchier.	Mr. Lionel E. Pilkington.
Mr. Vincent Bramall.	Mr. Alfred J. Tonge.
Mr. Leonard R. Fletcher.	Mr. Jesse Wallwork.
Mr. D. H. F. Mathews, H.M.I.M.	Mr. George H. Winstanley, F.G.S.
Mr. W. Ollerenshaw.	Mr. Percy Lee Wood.

HONORARY AUDITORS:

Mr. Vincent Bramall.	Mr. George H. Winstanley, F.G.S.

Mr. John Ashworth, in taking the chair, returned thanks for the honour conferred upon him in electing him President for the ensuing year. He greatly appreciated the honour, and would, he said, do his best for the interests of the Society.

Mr. James Ashworth read the following paper on "Air-percussion and Time in Colliery Explosions":—

AIR-PERCUSSION AND TIME IN COLLIERY EXPLOSIONS.

By JAMES ASHWORTH.

The writer, having carefully considered all the published information, and the reports of discussions on the Courrières explosion, has not found a theory which would satisfy what he has deduced as some of the leading indications, thus:—(1) In the Lecœuvre gallery (fig. 11, plate xxv.),* there was the clearest evidence of a developed force at a distance of 43 to 46 feet (13 to 14 metres) from the face of the gallery. Here the floor of the gallery was lifted, principally on the lower side, the tramroad-rails were forced towards the higher side of the road, and the lower-side rail was raised much above its normal level; two iron air-pipes (No. 139) were pounded into very small pieces (89 being counted); the roof at this point was much damaged, causing a heavy fall; one man (No. 129) was thrown outbye, with one leg and one arm torn off, and these were found further outbye than the body, which was also entirely denuded of clothes; a force also radiated from this point inbye and moved the ventilating air-pipes (Nos. 118, 119, and 120) out of position similarly to the tram-rails; the tram (No. 66) which was being loaded at the moment of the explosion, was driven inbye, clear of the end of the rails, and partly over the handle of a shovel (No. 64), the iron part of which was in the heap of coal at the face, whilst Leroy Regis, who had been using the shovel and loading the tram, was thrown on his back on to the top of the heap of coal, and, though his trousers were torn to pieces, the lower parts remained around his legs; his lamp (No. 46), still attached to the band of his hat, was found close to and not covered with coal; a one-ended pick (49) was lying on the top of the heap of coal, a hammer (No. 51) and wedge (No. 68) were in the middle of the level, close to the tram, but no miner's pick was found near the face; on the heap of coal was part of the coal-cutter trestle (No. 149), and on this

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 492.

lay the naked bodies of Arthur and Joseph Lecœuvre, with a prop and other wood on the top of all; many pieces of torn clothing were found between the tram and the lower side, also a plank off the tram, a very short bit of burnt fuze, and a miner's shoe; a torn hat in front of the tram; the lamp (No. 26) of Joseph Lecœuvre was found on the opposite side of the level to his body and 39 feet (12 metres) farther outbye; a small piece of fuze (No. 150) was found on the coal-cutter platform, another and the longest piece (No. 138) where the floor was disturbed, and another short piece (No. 28) between Henri Lecœuvre (No. 128) and his right arm.

(2) The box (No. 81) containing seven cartridges of No. 1 Favier powder, which had been taken out of store on the morning of the explosion, was found intact near the cut-through into the parallel heading; and near to, on the opposite side of the level, a short piece of burnt fuze (No. 25), and about 16½ feet (5 metres) outbye, on the same side, a ring of unburnt fuze (No. 9).

(3) No detonators were found.

(4) The remaining part of a shot-hole, in the face of the gallery, was similar to that of a shot-hole found in the face of the parallel heading.

(5) A comparison of the positions in which the tools in the gallery were found with those in the parallel heading gives a practical idea as to where the coal-cutter platform, the drilling-machine and drills would be placed when not in use, as the same men used them in both headings.

(6) In the Marie seam, north-east workings from the 1,070 feet (326 metres) north bowette of No. 3 pit, safety-lamps were alone used for lighting (fig. 8, plate xxii.).*

(7) These Marie-seam workings adjoined a fault, and no other seam of coal was worked below it on the north side of the pit (fig. 2, plate xvii.).†

(8) The indications of force from the Lecœuvre gallery were not directly towards No. 3 pit (fig. 7, plate xxi.).‡

(9) Where the recoupage or recovery-drift, at 1,070 feet (326 metres) joined the Marie seam north-east workings, there had been a door, the position of which was not exactly known; and therefore it was not possible to determine its projection, as there

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 492.

† *Ibid.* ‡ *Ibid.*

was a heavy fall of roof for a long distance on both sides of its place; to the south-east of the recoupage or recovery-drift, there was very good evidence of force by the inclination of timbers, all falling towards the south-east. To the north-west of the recovery-drift, there was an indication of force towards the north-west: the wheel of a tub was thrown 16½ feet (5 metres) away in that direction. There were contrary evidences of the same importance farther west in the Marie north-east district. In the recovery-drift itself, there was a very heavy fall of roof and no evidence of the direction of the force (Mr. G. Léon). The men in the Marie seam were all killed and burned.

(10) The indications of force emerging into the bowette at 1,070 feet (326 metres) from the Marie north-east district were both towards the north and the south in the bowette, and into the west workings of the Marie seam, but principally southwards towards No. 3 pit.

(11) The wet condition of the 1,070 feet (326 metres) north bowette did not restrain the flame of the explosion.

(12) No. 3 pit was the main downcast pit for all the seams affected by the explosion; and, therefore, as soon as it became choked with débris, the whole of the residual force of the explosion, and the deleterious gases produced, were compelled to attempt to find an exit principally through Nos. 2, 4, and 11 pits.

(13) Very heavy percussive effects were produced on the seams affected by the explosion.

(14) Two fires were discovered in the Joséphine workings between Nos. 2 and 3 pits,* some days after the explosion, and both were on the inbye side of goaves.

With these proved facts in mind, and considering the whole area of the mines affected by the explosion, it is practically certain that the explosion originated in the workings of No. 3 pit; that the centre of the demonstrated force was about the point where the return-air from the south-east Marie workings joined the recovery-drift at its western end; that there was practically a simultaneous explosion in the Lecœuvre gallery at a point 46 feet (14 metres) from the face, that is, where the air-pipe was broken into 89 or more pieces (fig. 11, plate xxv.); † that the upheaval or disturbance of the floor at this point indicated, either

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 451, and fig. 7, plate xxi.
† *Ibid.*, page 492.

an outburst of gas, or the accidental ignition or detonation of an explosive above the air-pipe. Now, as an outburst of gas could not smash the air-pipe in the way described, neither could a blown-out shot do so, and the writer prefers to conclude that an explosive, probably introduced into the pit surreptitiously, was ignited or detonated. There was no surveillance of the miners calculated to prevent them taking any sort of explosive into their working-places, especially in this gallery, where the men fired their own shots and were therefore uncontrolled. From the position of the drilling-machine and drills, the writer believes that Henri Lecœuvre was making a cartridge, and that the brothers Arthur and Joseph were carrying the drilling-tackle towards the face at the moment of the explosion.*

This supposition, however, does not apparently fit in with the fact that the largest part of a trestle, which was used in connection with the Sullivan coal-cutter, was found partly on the top of one of the brothers Lecœuvre, and the other brother on the top of the trestle, whilst the remaining part of it (No. 62) was found between the tram and the face of the level. The photographs taken by Mr. A. M. Henshaw show the positions of the bodies and materials so clearly, that everyone can decide for himself whether or not the force which piled up the men and materials in this manner went inbye or outbye, from the shot-hole, and whether or not a prop and other pieces of timber had followed the projection of the bodies. It does not seem possible to imagine any sort of force originating at the face which could force the bodies and materials into the positions shown (figs. 18 and 21).†

The writer's supposition that some explosive was accidentally fired whilst in the hands of Henri Lecœuvre would be very much strengthened if it were known what was the course ordinarily pursued by the Lecœuvre brothers, that is to say, whether they drilled the shot-hole and then holed the coal, or whether they holed the coal first and drilled the shot last. The plans show quite distinctly that it was possible to drill a hole whilst Regis was loading the coal, but impossible to hole the coal; and as these men do not seem to have had any other work to do than prepare

* After the Fernie colliery explosion in 1902, one of the miners was found with a piece of paper rolled on a pick-elve, to make a cartridge, and yet no hole was drilled ready for a shot.

† *Trans. Inst. M. E.*, 1906, vol. xxxii., pages 469 and 472.

a shot-hole, this appears to be the most practical supposition. In some confirmation of this supposition, there is the fact that the longest piece of burned fuze was found at the point where the air-pipe was smashed into fragments, and the drilling-tackle in the middle of the road.

This explosion conveys the very strong impression that it was of a complex character, (1) that it originated in or near to the north-east Marie workings in No. 3 pit, where there was a single door which might have been open ; (2) that the indications of force were found to radiate from this point, and also to a less extent from the Lecœuvre gallery ; (3) that the explosion in the Marie seam produced a detonating or percussive effect on the Lecœuvre gallery and fired an explosive compound; (4) that the enormous air-pressure resulting from these almost simultaneous explosions was completely bottled up by the caving in of No. 3 pit; (5) that the burning effects, coking of dust, and enormous volumes of carbon monoxide were caused largely by air-pressure, and not by what is termed a "coal-dust explosion." Coal-dust doubtless added to the force of the explosion at its initiatory points, but the main cause of the extent and magnitude of the disaster was air-percussion.

The writer does not expect that many students of colliery-explosion phenomena will at first agree with his deductions as to the effect of percussion; but he is supported by actual facts, and particularly by a disaster which occurred in the Mount Kembla mine in New South Wales in 1902, when 95 lives were lost in a mine free from fire-damp, and where every man used an open light. Shortly stated, that disaster resulted entirely from a huge fall of roof, which so heavily compressed the air along one particular haulage-road as to create enormous volumes of carbon monoxide and damage, which was entirely confined to the haulage-road. The dust thus lifted off the floor and sides was carried along like a bullet in a gun, and became so highly heated by pressure and friction that, on being disseminated in the outer air, it burst into flame, wrecking the surface plant, setting materials on fire, and burning and killing several persons.*

Probably every large colliery-explosion in Great Britain has demonstrated percussive or detonating effects, and only one of

* *Mount Kembla Colliery Disaster, 31 July, 1902: Report of the Royal Commission, together with Minutes of Evidence and Exhibits*, Sydney, 1903.

these, at Udston colliery, has received official recognition, namely, in the report of Mr. Joseph Dickinson,* but the writer thinks that this phenomenon has not been followed up by its diagnoser, or by any other investigator excepting himself.

At the Fernie mine in British Columbia, peculiar effects were observed and were attributed to the inexplicable vagaries of colliery-explosions, whereas they became perfectly clear when examined by the aid of the percussive or detonative theory and as resulting from practically simultaneous explosions of nearly every can containing powder in every part of the mine affected by the explosion. This explosion was described in a paper,† contributed to The Institution of Mining Engineers in 1902, as a coal-dust explosion, but it had none of the characteristics of a coal-dust explosion: that is to say, it did not traverse the main haulage-road, but developed its greatest force from the gas in the main return-airway, from which road the force swept broadside on and crossed the main haulage-road through practically every stopping, from east to west. In the case of Fernie, as at Courrières and at Mount Kembla, the agent most destructive to human life was carbon monoxide and not flame.

One other point of the greatest importance in the elucidation of colliery-explosion phenomena is that of "time"; thus, if we follow the popular idea of a coal-dust explosion, time must be allowed for the distillation of gas, the ignition of this gas, and many repetitions of this process; but, unfortunately for the theory, there is no evidence of such a period of time as would be necessary thus to carry flame throughout the ramifications of a mine like Courrières. Taking the latter as an example, the evidence showed that instead of the force increasing after it had caused the blockage of No. 3 shaft, it actually decreased, was not perceptible at the top of No. 2 shaft, and did very little damage at the tops of Nos. 4 and 11 shafts. Had the precise time of the arrival of the explosion-effects at the tops of, say, Nos. 3 and 4 shafts been taken, very valuable information would have been added to our knowledge of colliery-explosions, and the writer is confident that it would have proved that an explosion is

* *Explosions (Udston Colliery): Report to the Secretary of State for the Home Department*, by Messrs. J. Dickinson, H.M. Inspector of Mines, and C. C. Maconochie, Advocate, 1887 [C.—5192].

† "The Fernie Explosion," by Mr. W. Blakemore, *Trans. Inst. M. E.*, 1902, vol. xxiv., page 450.

more or less of an instantaneous character. It has been observed in all cases where smoke and dust have been projected from the pit-tops or other openings, that this effect only occupies a few seconds of time, and that the column of dust is then cut off as if by a knife, part immediately rushing back into the workings to fill the vacuum caused by the condensation of the heated gases and steam, and thus causing backlash and other contrary effects underground.

The instantaneousness of a colliery explosion is also clearly demonstrated by the positions in which men are found, many of them in the precise positions in which they were at the moment, such as eating food, and the effect on men who have escaped alive has been of such a temporary character as not to alarm them or cause them to cease work, although the sudden pressure of the air has always been noticeable in the stoppage of watches on the persons of both the living and the dead. Nothing could more convincingly show the instantaneousness of colliery-explosions than such facts as these, coupled with the firing of shots and powder cans at distances of upwards of a mile from the point of origin, as at Tylorstown and Fernie collieries.

The importance of taking time into account when looking for the point of origin of an explosion, was demonstrated by the explosion at the Albion colliery in 1906.* There were two falls of roof on a main level at a distance of 240 feet apart, and the evidence given by the men working at the one nearest the pit-shaft was that the explosion occurred about 5 minutes after the largest fall took place, and that the volume of air was 20,000 cubic feet per minute passing along a level which at the double parting was 13 feet wide. The roughest calculation will show that any gas given off by this fall must have passed the second fall long before the explosion took place, and that it was therefore the second fall that forced flame through a sound bonneted Clanny safety-lamp placed on the floor immediately underneath, where it was subsequently found by the first explorers.

* "Report on the Accident at Albion Colliery," by Mr. F. A. Gray, H.M. Inspector of Mines, *Reports of W. N. Atkinson, H.M. Superintending Inspector of Mines, and F. A. Gray and J. Dyer Lewis, H.M. Inspectors of Mines, for the Cardiff and Swansea Districts (Nos. 10 and 11), to His Majesty's Secretary of State for the Home Department, under the Coal Mines Regulation Acts, 1887 to 1896, the Metalliferous Mines Regulation Acts, 1872 and 1875, and the Quarries Act, 1894, for the Year 1906*, 1907 [Cd. 3449—IX.], page 24.

The caving-in of No. 3 shaft at Courrières collieries caused similar effects to that of bursting a boiler by holding down the safety-valve, and as all the haulage-road connections with Nos. 4 and 11 shafts were close to No. 3 shaft on the south bowette, the pent-up force had naturally to expend itself in that direction. Although the Ste. Barbe and Cécile roads were either too dirty or too dusty to carry flame, yet the mechanical effects of the explosion were demonstrated along them all the same.

The writer is of opinion that the Courrières disaster was only to a certain extent a coal-dust explosion, and that the partial coking of dust, burning effects on some of the bodies, and the huge production of carbon monoxide, were due to percussive effects and not to actual flame, excepting only where flame was produced by the firing of stores of explosives at various points, as at Fernie colliery.

The most important lesson taught by the Courrières explosion, as well as by some colliery-explosions in this country, is not that of the danger of working a large number of mines connected together for convenience of ventilating arrangements; but the danger of having shafts so insecurely lined and so filled with material, bratticing especially, that either an explosion or an accident with the winding-arrangements may cause a block in the shaft and entirely preclude all hope of saving the majority of the persons underground. Consequently, if No. 3 pit at Courrières collieries had remained open, and the rescue-parties could have entered the mine without delay, the loss of life would have been comparatively small.

Mr. Joseph Dickinson (Pendleton), in moving a vote of thanks to Mr. James Ashworth, said that observations on the time occupied in explosions were rather rare, persons at such times having usually their attention otherwise occupied. To some extent he agreed with what was stated by Mr. Ashworth in his paper, but not entirely. Indeed, of the many explosions that he had investigated, he never but once actually took the time. On one occasion he felt the suck, and, guessing what was coming, he lay down in the gutter until the blast had passed: it seemed to occupy a long time. Times would most likely vary with the quantity of gas, its mixture with air, and the point of ignition. In former times, when

gas was burnt out to admit of shots being fired, he had seen the flame travel slowly.

The explosion which he timed occurred in the Limehurst colliery, Ashton-under-Lyne, where three seams of coal were being worked. On August 5th, 1884, the Two-feet seam was giving off fire-damp freely; and, as height was required in the roadways, blasting was resorted to under the restrictions, including ordinary work-persons being out of the mine. At one part fire-damp began to issue very freely, causing the manager to issue a written notice forbidding blasting. Notwithstanding the notice, a shot-lighter fired a shot, and lighted the issuing gas. He tried to flap out the flame, but failed. The manager was called, and came forthwith with help, and they did what they thought best, but without much effect; and soon afterwards the consulting mining engineer arrived. Efforts were continued, the flame kept burning, and gas kept flashing at intervals overhead, tumbling the party about until they became disheartened. Mr. J. S. Martin, then Assistant-Inspector of Mines, arrived; and another effort was made, about twelve fire-extincteurs being applied, but the gas kept burning as it issued, and the packing took fire. He (Mr. Dickinson) visited the colliery, and found that it was being flooded with water, but with air still passing through the workings, and that it would take at least a fortnight before the water could rise high enough to shut off the air from the fire, during which time the fire would be spreading. It was resolved to shut off the fire; but with so much gas it was thought unsafe to do so by building stoppings or by closing the top of the shafts; it was, therefore, arranged to use two wooden air doors which, with a little preparation and some sand, could be quickly closed tightly. Preparations being thus made, all ascended the shaft and a consultation was held. Four volunteers undertook the closing, and descended the shaft. In 10 minutes, having closed the doors, they re-ascended; and, 13 minutes later, the mine exploded, going off like the crack of artillery. Dense black smoke flowed out of the upcast shaft, and continued for nearly half-an-hour. Two of the volunteers were members of this Society, Mr. Robert Winstanley and Mr. Walter Evans. The disobeying fireman was prosecuted, and fined 5s. and costs: a trifling sum compared with the damage done. Had building-off instead of closing-doors been adopted on this occasion, all the persons engaged in the operation would have been lost.

The suggestion made by himself (Mr. Dickinson), as to percussion or detonation of air assisting the explosion at Udston colliery, was, he thought, concurred in by Mr. Ralph Moore, H.M. Inspector of Mines for the district.

He agreed that dust was only a contributor, and not the main factor of the Courrières explosion. He had previously stated his view that it originated from fire-damp, and was helped on by dust and gas in the air and goaves, notably in the just-shut-off area surrounding the fire. He had hoped for some explanation of one of the shutting-off stoppings shown on the plans as being in a main airway; but, so far, none had reached him.

Mr. HENRY BRAMALL (Pendlebury), in seconding the resolution, said that he would like to know the amount of compression that must be produced in air before the temperature became so high as to fire gas: and he could not see how it was possible for the air in a mine to become so compressed as to acquire that heat. He would also like to know how carbonic oxide could be generated by compressing air. No doubt Mr. Ashworth had some explanation, or the terms in question would not have been used by him; but, so far, he was at a loss to understand those points of the paper.

The resolution was carried.

Mr. JOSEPH DICKINSON said that perhaps Mr. Bramall had forgotten or did not know Dr. Angus Smith's invention for testing fire-damp; air mixed with a small percentage of fire-damp became readily ignited by compression. Mr. Dancer made a similar instrument, and with it he (Mr. Dickinson) experienced no difficulty whatever in producing sparks from fresh air, although it fired much more readily with a mixture of fire-damp. It had one peculiarity, that, the air having once been fired, a second spark could not be obtained from the same volume of air.

Mr. HENRY BRAMALL knew the scientific toy referred to by Mr. Dickinson. Granted that one could fire tinder by the compression of the air in this toy (as only a very moderate temperature was needed), even that compression was very much greater than could take place in the airways of a mine. He had had little experience of explosions, and might be wrong, but he could not conceive how so great a compression could be produced in a mine as was required for Mr. Dickinson's experiment.

Mr. James Ashworth said that he did not think that anyone thoroughly understood percussion or detonation as demonstrated by colliery-explosions; and he purposely brought this matter forward for discussion, because it was a subject which required thoroughly well ventilating. If a mine were watered, and either percussive or detonative effects were produced, then watering could exercise very little protective value. Members would perhaps have noticed on the plan accompanying the report of the Llanerch explosion* of February 6th, 1890, that some curious percussive effects were demonstrated. The men in the lower-side headings, and at the ends of the levels, were found dead just where they were at work, and showed appearances of burning; whilst the men on the higher side, where there was more air-room, were able to run a considerable distance before they succumbed to the after-damp. This explosion occurred in a mine worked by open lights. With regard to detonation or percussion, whichever was demonstrated in fiery colliery-explosions, he understood Prof. H. B. Dixon to say, in his evidence given before the Royal Coal-dust Commission, that no such thing as detonation could occur, and that the propagation of flame in a fire-damp mixture was not very rapid;† but later he noted that Prof. Dixon had spoken about the detonation of mixtures of air and fire-damp. At the Altofts colliery explosion, gas was set on fire in the goaf and he (Mr. Ashworth) thought that it was caused by detonation or percussion; but Mr. W. E. Garforth assured him that it was caused by actual flame from the explosion. Whatever caused the actual ignition, it was certain that its extinction under the most dangerous conditions was only accomplished and a further disaster averted by the cool-headed bravery of Mr. Garforth and his devoted officials and workmen. After the Universal colliery-explosion, the expert witnesses could not agree whether the disaster originated on the east or on the west side of the shafts, nor in which district it commenced; but the plans showed that the force of the explosion came from the different districts towards the main haulage-road. Nevertheless, the only man who came out alive was in a direct line between the east and the west districts, and,

* *Report to H.M. Secretary of State for the Home Department upon the Circumstances of the Llanerch Colliery Explosion and the Inquest Consequent thereupon*, by Mr. H. D. Greene, Q.C., 1890 [C.-6098], page 10 and plan.

† *First Report of the Royal Commission on Explosions from Coal-dust in Mines*, 1894 [C.-7401.-I.], vol. ii., minutes of evidence, with appendices and index, appendix xxi., page 91.

consequently, if actual flame passed from either side to the other, it must have gone over him. Did it pass over him? In his (Mr. Ashworth's) opinion, it did not.

It remained to be proved whether there was not another factor to be reckoned with in colliery-explosions, namely, that of electricity. He had thought sometimes that there were electrical conditions which concerned colliery-explosions, but had been assured by electricians that they were impossible; still later he had found that other people were considering the electrical possibilities—for instance, that damp coal-dust in the air carried a charge of negative electricity.

In the case of the explosion described by Mr. Dickinson, it was marked by smoke coming away from the fire. Smoke might deaden the speed, or add to it according to the condition of the fire, but he thought that it would most probably lower very considerably the speed of the explosion.

He (Mr. Ashworth) would be pleased to have the questions that he had raised thoroughly discussed, particularly at the present time, when watering was generally considered to be a necessary safeguard against the extension of colliery-explosions; whereas, if detonation or percussion occurred, it was most probable that the extension of an explosion would be facilitated rather than retarded by watering and spraying.

Mr. W. A. Ritson moved that the thanks of the Society be tendered to the officers and Council for the past year.

Mr. Gerald H. J. Hooghwinkel seconded the resolution, which was cordially approved.

THE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

ANNUAL GENERAL MEETING,
HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
OCTOBER 7TH, 1907.

MR. JOHN NEWTON, RETIRING PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentleman was elected:—

ASSOCIATE—
Mr. AMOS BIRCHALL, Goldendale Ironworks, Chatterley.

The Annual Report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1906-1907.

The Council report that 1 honorary member, 5 members, 3 associate members, 3 associates and 1 student have been elected during the year. The transfers have been 1 associate and 4 students to members, and 3 students to associates. Six members have resigned, and 1 honorary member and 2 members have died. There were 192 names in the list of members on August 1st, 1907, as compared with 216 a year previously.

Much regret is felt that many members fall into arrears with their subscriptions; and, after affording every opportunity to those so placed to continue their membership, the Council have been obliged to erase the names of 12 members, 1 associate member, 12 associates, 3 students (or a total of 28 names), and their arrears amounting to £167 9s. 6d.

During the year, general meetings were held in November, December, February, April, June, and July, with an excursion-meeting at the gypsum-mines and works at Tutbury in June last.

In addition to the above, the seventeenth annual general meeting of The Institution of Mining Engineers was held in Hanley in September, 1906, at which there was a large attendance of members.

The following papers were read during the year:—

"The Courrières Explosion," by Messrs. W. N. Atkinson and A. M. Henshaw.

"Improved Construction of Rails and Rail-joints for Collieries, Mines and Quarries," by Mr. J. Bentley.

"Outbursts of Coal and Gas in the Cockshead Seam, Shelton Colliery," by Mr. F. E. Buckley.

"A Gob-fire in a Shropshire Mine," by Mr. St. V. Champion Jones.

The Council have decided to award prizes as follows for these papers:—The President's prize, value £4 4s., for Messrs. W. N. Atkinson and A. M. Henshaw's paper on "The Courrières Explosion," and a second prize, value £2 2s., for Mr. F. E. Buckley's paper on "Outbursts of Coal and Gas in the Cockshead Seam, Shelton Colliery." The Council wish to thank the President for kindly adding £3 3s. to the value of the prizes awarded. The Council desire to record their high appreciation of the valuable paper on "The Courrières Explosion," and to tender to the authors their best thanks for the time and labour that they must have given to the subject.

With a view to encouraging the writing of papers by the members, the Council renew the offer of prizes, of the value of (*a*) £3 3s. and (*b*) £2 2s., for the best paper read at general meetings during the current year by (*a*) members and associate members, and (*b*) associates and students, provided that the Committee of Selection consider the papers of sufficient merit to justify the award.

Owing to the question of the federation of the Pottery Towns being under consideration during the past year, and the uncertainty as to the ultimate decision arrived at, the question of the proposed Technical College is in abeyance.

The mining classes held in the coal-field were very successful, being attended by 404 students; and it is pleasing to note that one of them, Mr. A. E. Cooke, was a winner of the Institute prize for his "Notes on the Feed-water of Colliery Boilers." The prize distribution took place at Stoke-upon-Trent on November 17th, 1906, before a large gathering of mining engineers and students. An address was given by Principal Hopkinson, of the University of Manchester.

Dr. The Treasurer in Account with The North Staffordshire Institute of Mining and Mechanical Engineers for the Year Ending July 31st, 1907. Cr.

	£ s. d.	£ s. d.	£ s. d.
August 1st, 1906.			
To Balance			127 16 7
July 31st, 1907.			
To subscriptions for the year 1906-1907		294 13 6	
,, arrears received for the year 1905-1906	39 13 0		
,, ,, ,, 1904-1905	11 9 6		
,, ,, ,, 1903-1904	4 4 0		
,, ,, ,, 1894-1895	2 2 0		
		57 8 6	
		352 2 0	
Less subscriptions for 1906-1907, received prior to August 1st, 1906		4 4 0	
			347 18 0
To subscriptions for the year 1907-1908, received in advance			4 4 0
,, sales of annual dinner tickets		7 3 4	
,, ,, Prussian Reports		0 6 0	
,, ,, *Fossil Charts*		0 5 0	
,, ,, Excerpts		1 15 6	
			9 9 10
,, ,, dinner tickets for meeting of The Institution of Mining Engineers...			23 15 0
,, donations to fund for prizes			3 17 0
,, ,, Ward Testimonial fund...			6 15 6
			£523 15 11

I have examined the foregoing account with the books and vouchers, and certify the same to be correct.

W. H. EARL,
Chartered Accountant.

Newcastle-under-Lyme, *September 11th*, 1907.

	£ s. d.	£ s. d.
July 31st, 1907.		
By the Institution of Mining Engineers:—		
Calls for 1906-1907, 151 at 19s. ...	143 9 0	
,, 1905-1906, 25 at 19s. ...	23 15 0	
Supplying *Transactions* to 15 members	15 0 0	
Proportionate cost of exchanges ..	1 6 3	
		183 10 3
,, printing and stationery		31 6 6
,, storage of books	1 1 0	
,, rent of rooms	9 12 6	
		10 13 6
,, secretary's salary and expenses ...	67 0 9	
,, treasurer's postages, etc.	1 10 5	
,, reporter's salary and expenses ...	14 0 0	
,, fire-insurance premium	0 12 6	
,, cheque-book	0 10 0	
		83 13 8
,, library account	11 9 3	
,, librarian's salary	5 0 0	
		16 9 3
,, annual dinner, exhibition, etc.		21 12 0
,, expenses of meeting of The Institution of Mining Engineers		44 13 2
,, prize-account		9 2 0
,, accounts owing on July 31st, since paid		37 12 0
		£438 12 4
,, Balance in Bank:—		
J. Ward's testimonial fund account ...	6 15 6	
Institute account	78 8 1	
		85 3 7
		£523 15 11

Dr. THE TREASURER OF THE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS IN ACCOUNT WITH SUBSCRIPTIONS FOR THE YEAR 1906-1907. **Cr.**

	£ s. d.	£ s. d.
To 123 members and associate members at £2 2s.	258 6 0	
,, 9 honorary members		
132		
,, 39 associates at £1 6s.	50 14 0	
,, 18 students at 15s. 6d.	13 19 0	
		322 19 0
189		
,, subscriptions for the year 1907-1908, received this year	......	4 4 0
,, arrears brought forward from 1906 ...	241 8 0	
,, *less* written off and allowed by Council	167 9 6	
		73 18 6
		£401 1 6

		Paid. £ s. d.	Unpaid. £ s. d.
By 114 members and associate members at £2 2s., ...		239 8 0	......
,, 9 members and associate members unpaid, at £2 2s.		......	18 18 0
,, 9 honorary members		......	......
132			
,, 33 associates, at £1 6s.		42 18 0	......
,, 6 do. unpaid, at £1 6s. ...		......	7 16 0
39			
,, 16 students, less 6d. underpaid, at 15s. 6d.		12 7 6	......
,, 2 students unpaid, at 15s. 6d. ...		......	1 11 6
18		294 13 6	23 5 6
189			
,, subscriptions for the year 1907-1908, received this year	£4 4 0		
,, arrears received this year	57 8 6		
		61 12 6	......
,, arrears outstanding on July 31st, 1907		......	16 10 0
		£356 6 0	44 15 6
			356 6 0
			£401 1 6

ANNUAL REPORT OF THE TREASURER, 1906-1907.

The Treasurer submitted the following statement of the accounts for the year ending July 31st, 1907:—

The total receipts amounted to £395 19s. 4d., of which £290 9s. 6d. is for current year's subscriptions, £57 8s. 6d. received for arrears, £4 4s. received for subscriptions paid in advance, £37 1s. 10d. for sundries, and £6 15s. 6d. donations to the "Ward Testimonial Fund." Of last year's arrears of £241 8s., there has been written off £167 9s. 6d., leaving £16 10s. to carry forward, after deducting the above sum of £57 8s. 6d. The present year's arrears are £28 5s. 6d., making altogether a total of £44 15s. 6d. of outstanding arrears.

Owing to extra expenses incurred during the year, the result of the year's working has been to decrease the credit-balance of the Institute from £127 16s. 7d. to £78 8s. 1d.

ANNUAL REPORT OF THE LIBRARIAN, 1906-1907.

The Librarian (Mr. F. H. Wynne) reported as follows:—

During the past year, 28 volumes have been bound and added to the library of this Institute. These include, besides the current parts or numbers of the *Transactions* of kindred societies received in exchange during the period, some volumes of previous years that have remained unbound on account of missing parts that had been lost in the several removals to which the library has been subjected, or which for some reason or other unknown have not come to hand. Efforts are still being made to remedy further defects of a similar nature, with a view to obtaining as nearly as possible a complete sequence of each set of *Transactions*. It is to be regretted that so little progress has been made since the last report towards an object so desirable as that of a building suitable to contain the valuable and extensive collection of literature to which this report refers.

The CHAIRMAN (Mr. John Newton) moved the adoption of the reports.

Mr. R. H. COLE seconded the adoption of the reports, and the motion was carried.

ELECTION OF OFFICERS, 1907-1908.

The following officers of the Institute were elected for the ensuing year:—

PRESIDENT:

Mr. G. P. HYSLOP.

VICE-PRESIDENTS:

Mr. J. R. HAINES.	Mr. A. HASSAM.	Mr. J. T. STOBBS.

TREASURER:

Mr. THOMAS ASHWORTH.

SECRETARY:

Mr. F. R. ATKINSON.

COUNCILLORS:

Mr. F. E. BUCKLEY.	Mr. HUGH JOHNSTONE.	Mr. WILLIAM STATHAM.
Mr. W. G. COWLISHAW.	Mr. G. E. LAWTON.	Mr. W. TELLWRIGHT.
Mr. G. H. GREATBATCH.	Mr. WILLIAM LOCKETT.	Mr. JOSEPH WAIN.
Mr. JOHN GREGORY.	Mr. THOMAS ROBERTS.	Mr. F. H. WYNNE.

Mr. W. G. COWLISHAW said that he had very great pleasure in proposing a vote of thanks to the retiring President for the valuable services that he had rendered during the year. When he took office last year, he told them plainly that he was not a scientific man, and would not be able to carry on his presidency on purely scientific lines, but that he was a business man and would carry on the business of the Institute from a business point of view. Personally, he thought that it was good for every institution, scientific and otherwise, to have at its head a business man every few years so as to put matters on a proper business basis, for often scientific men were but poor business men.

The PRESIDENT (Mr. G. P. Hyslop), in seconding the vote of thanks, said that they would never have a more practical President than Mr. Newton had been, and the members owed a debt of gratitude to him for having during his year of office placed the Institute on a more business-like footing than it had occupied for many years past.

The vote of thanks was carried unanimously.

Mr. JOHN NEWTON said that he had felt very proud on being elected President: in fact, he considered that it was the proudest

position that a business man in North Staffordshire could occupy. All the best scientific men connected with the trade of the district should be associated with their Institute, and his feeling of regret was that they had not made the progress that they ought to make, and that they did not get the support that they ought to get from colliery managers and students. Moreover, they ought to have a greater number of able papers than they were having, and that would create an interest which did not already exist.

Mr. G. P. Hyslop delivered the following "Presidential Address":—

PRESIDENTIAL ADDRESS.

By G. P. HYSLOP.

It is my first duty to offer you my thanks for having done me the honour to elect me your President for the ensuing year. The position is one which has frequently been occupied by mining engineers of conspicuous ability and great knowledge, and its duties involve a responsibility which I can only undertake with diffidence. It is, I am afraid, a fact, as was stated by the Retiring-President (Mr. John Newton) in his Address last year, that it is necessary to infuse greater vitality into the proceedings of the Institute than has been apparent during the past few years, and one's sense of the responsibility of the position is deepened by that knowledge. With the aid of the Council and members, it should not be impossible to restore to our proceedings some of their former vigour, and to give to the very valuable papers which are from time to time presented to the Institute that proper and comprehensive discussion to which they are entitled. The interchange of thought and opinion, which it is the object of this Institute to promote, is of the greatest utility and assistance to the members in their professional work, and its utility is enhanced when the discussions are entered into, not only by those members who have acquired a wider experience, but also by the junior members, who bring fresh minds, unfettered by tradition, to bear upon the many important subjects which the Institute has to consider. In asking you for a greater measure of support for the Institute, I would appeal equally to those gentlemen who have done such excellent service for it in the past, and to students from whom so much is to be required in the future, as well as to the ordinary member; and, for myself, I can only undertake that, so far as lies in my power, I shall endeavour to maintain its vigorous existence.

It frequently occurs that Presidential Addresses are of a somewhat reminiscent character, and as this meeting is the twenty-first consecutive annual meeting of the Institute at which I have been present, I propose, before turning to another subject, to review briefly some of the changes and incidents of

the last two decades which have affected the Institute and the industry with which it is more particularly allied.

It is precisely twenty years ago since the members of this Institute accepted the invitation of The North of England Institute of Mining and Mechanical Engineers to a meeting at Newcastle-upon-Tyne, where we were most hospitably received, and were privileged to listen to a paper on "The Mining Institutions of Great Britain,"* read by Mr. Theophilus Wood Bunning, then the Secretary of the North of England Institute. That paper first put into a tangible form the scheme which had been for a long time in many people's minds, namely, the federation of the various mining institutions and societies into one body. The scheme has never been realized in its entirety, but it was supported by our local Institute in 1889, although it did not become federated until 1891, since which time we have remained members of The Institution of Mining Engineers. It cannot be disputed that we have derived great benefits from this federation. We receive numerous papers on every conceivable branch of mining, which in themselves form a very complete library of technical literature; and at the large gatherings which assemble for the General Meetings of The Institution of Mining Engineers we have the opportunity of coming into contact with the thought and progress of other districts, an opportunity which would not have been ours unless we had joined the federation. It was perhaps inevitable that our local Institute, which is representative of a comparatively small mining district, should have been to some extent overshadowed by sister institutes having older traditions and greater resources both of wealth and numbers; but it is regrettable that, from the time of our federation, there appears to have been a check in the progress of this Institute in individual work and effort. In spite of this, however, our members have contributed recent papers of very great value, some of the geological contributions being of quite a unique character; and we may hope that our *Transactions* will continue to be worthy of a district which possesses so many extraordinary features of mining interest, and which I venture to think is likely to be of increasing importance among the mineral districts of Great Britain. In one

* *Trans. N. E. Inst.*, 1887, vol. xxxvi., page 167.

other respect the federation of the various mining institutes appears to have been disappointing, and not to have fulfilled the hopes raised at its foundation, and that is with regard to the status of its members. It was hoped that membership of The Institution of Mining Engineers would have carried with its title some indication of the qualification of a member in his profession. The proper gradation of membership, such as is carried out by other technical societies, must contribute to the dignity of The Institution of Mining Engineers and ultimately add to its prosperity and its influence. The difficulties of effecting any change are, no doubt, very great; but it is to be hoped that the earnest attention which the subject is receiving at the hands of a Committee of the Institution will produce some practicable proposals.

If I venture to refer briefly to the question of labour, it is because it forms the heaviest individual charge in the production of the material in which we are chiefly interested, and its organization and efficiency are fit and proper subjects for our consideration. Those great industrial struggles that have in past times interfered with the progress of the mining industry have been unheard of in late years, and the past two decades have seen great strides made in the methods of adjusting such differences and disputes as must from time to time take place. The Joint Board of the Coal-owners' and the Miners' Federation has ensured to the industry the peaceable regulation of the rates of wages of employés, and in our own locality, at any rate, there has been an increasing tendency to settle minor disputes by common sense and reason. These are matters to be recorded with some gratification, but it may be well to ask ourselves whether, in spite of the aid of greatly improved machinery and appliances, the tendency of modern labour organization has been to maintain the productive efficiency of the mines of the district. It is perhaps impossible by the aid of such statistics as are, so far as I know, available to give a definite opinion upon this point: but it may not be without value to devote some little time to the examination of a comparison of some of the yearly outputs of this district of North Staffordshire. The factors which chiefly affect the returns of the output of minerals per person, which are annually published by the Home Office, are as follows:—

(1) The proportion of the various classes of minerals produced, chiefly that of ironstone to coal, the quantity of minerals other than these that are being produced in this district being so small as to be almost negligible.

(2) The proportion of seams of different thickness or productive character which are being worked.

(3) The number of days on which minerals are being produced.

(4) The rate of production of the individual labourer, by whatever cause it may be affected.

It is probable that each and all of these causes have had their effect in the somewhat remarkable fall since 1886, during which year the production of minerals per person employed underground in North Staffordshire was 472 tons, whilst in 1906 it was only 365 tons. In 1886, however, the production of ironstone in North Staffordshire was 24·3 per cent. of the gross tonnage of minerals produced, and coal was 75·2 per cent., whilst, in 1906, ironstone was only 13·4 per cent. and coal was 86·3 per cent. But, as the ratio of ironstone to coal only fell about 11 per cent. and the output of minerals per person fell nearly 22½ per cent., it is obvious that other factors must have considerably influenced this result. I do not think that it can be contended that, taking the district as a whole, the seams worked are less in thickness or productive character than they were twenty years ago. It has not been necessary, as in some other parts of this country during the last few years, to commence working seams which had been hitherto impossible to work economically; and, therefore, it may, I think, be inferred that the two last-mentioned causes, namely, the number of days worked (which for these two years are not recorded) and the rate of production of the labourer, had considerable influence in this alteration.

Some light may be thrown on the subject by an examination of the Government reports between the years 1897 and 1905, when a return was given of the shifts which might have been worked by each person employed in or about the mines. If the number of these shifts be divided into the output of minerals for the year for each person employed underground, the result should be a figure which, at any rate for purposes of comparison, will indicate the output per shift per person for whom there was pit-room, and therefore will reflect, not only the

actual production per man, but also the extent to which the man availed himself of the opportunities for employment.

The following table gives these figures, together with the percentage of the output of ironstone to the gross output of minerals:—

Year.	Shifts which might have been worked.	Output of mineral per person employed belowground.	Yields per possible shift.	Percentage of output of ironstone of gross output.
		Tons.	Cwts.	Per cent.
1897	275	427	31·05	15·0
1898	279	440	31·05	16·8
1899	287	417	29·05	16·0
1900	289	397	27·05	15·6
1901	270	350	25·09	12·4
1902	276	341	24·07	11·4
1903	252	332	26·03	10·5
1904	269	342	25·04	11·9
1905	256	343	26·08	13·0

These figures show a gradual fall in the yield per shift over the greater part of the period under consideration. As I have previously remarked, the falling ratio of ironstone-output in North Staffordshire is, no doubt, to some extent responsible for the declining yield; but that it is not the sole or direct cause may be inferred from a consideration of the figures. Between the years 1897 and 1900 the proportionate output of ironstone was more than maintained, yet the output per possible shift fell nearly 3½ cwts., or about 11½ per cent.; and, although there was a fall in proportionate output of ironstone (about 4·2 per cent. by 1902), yet the yield per possible shift fell to its lowest point, a further drop of 2·8 cwts. from 1900, or nearly 10 per cent. Again, there was a further decrease in 1903 of the proportionate output of ironstone, yet in this year there was a recovery of 1·6 cwts. in the yield. One, and a very obvious, reason of the fall of the yield may be ascribed to the high rates of miners' wages, which rose between the years 1897 and 1901 from 30 to 60 per cent. above the standard of 1888; while the subsequent recovery in the yield after 1902 was coincident with, though not proportionate to, the decrease of 20 per cent. in the rates of wages which occurred between the July of 1902 and 1904.

I do not propose to dwell upon this aspect of the question. It is a wellknown, though a regrettable, fact that high rates of wages have influenced the time worked; but there is perhaps

a ray of comfort to be extracted from the comparison in reference to the proposed legal limitation of the hours of labour underground. Whether the hopes of the advocates of this limitation—that it will be followed by an improvement in the rate of individual output, either by improved attendance or by increased exertion—will be realized are matters which the future will alone discover. What immediately concerns us is the fact that it is apparent that the working-faces of the mines must be more extensive to meet this falling yield; and it is on the mining engineers of the district that the responsibility lies of meeting the changed conditions, even over so short a period as that to which I have referred. While we have been devoting our attention to improvements in machinery, to the introduction of new and more perfect methods of applying power underground, to the concentration of output, and similar matters, in order to facilitate and cheapen production, is it not possible that we have lost sight of, or accepted as inevitable, the counteracting effects which these returns appear to establish? At any rate, I would suggest that a very proper subject for the consideration of mining engineers in this district is the question of the possibility of effecting some improvement in the organization of labour, particularly at the coal-face.

Questions of health and safety are amongst those which have been so frequently reviewed in addresses of this character, that I will not occupy your time by referring to them other than very briefly. While so very much is being done in the perfection of mechanical appliances to provide for safety, there still occur a large number of accidents, in some cases causing many deaths, arising from amazing ignorance or neglect of commonsense precautions. Such excellent work is being done by the County Council instructors that we may, I hope, anticipate a supply of underground officials possessing much greater knowledge; but at present it must be regretted that, while many of the younger men are availing themselves of the mining instruction given, it cannot reach more extensively the miner possessing some years of working-experience at the face who, as experience teaches us, makes the best sub-official. In my own recollection of the district, however, no greater strides have been made in the direction of safety than in the ventilation of mines.

And this has been brought about, not only by the provision of more powerful ventilating machinery, but also by the better comprehension of officials of the necessity of careful distribution and concentration of ventilating-currents in the workings.

There is probably no district in the United Kingdom where so large a proportion of its output is being raised from great depths as North Staffordshire, and the subject of the future development of its deep mines is one that must always be of peculiar interest to this Institute. Already there are three collieries in the district winding coal from a depth of approximately half-a-mile, and it is quite within the bounds of possibility that some of the present junior members of the Institute will be called upon to undertake the working of coal at depths approaching 4,000 feet, which depth has been fixed by two Royal Commissions as the probable limit of the practicable mining of coal. While, however, workings may be extended to such great depths, it does not follow that it will be necessary or desirable to sink main shafts to such depths. In fact, in the highly-inclined seams of the district, it is possible that coal at great depths will be reached from shafts not very considerably deeper than the deepest now in existence. It has been generally conceded that the engineering difficulties do not offer any insuperable obstacle to winding coal from deeper shafts than any now in use in this country; and, although there must be a limit, with greater depth, to that great increase of output per shaft which is being accomplished in some of the more modern plants, particularly in Yorkshire, yet it seems probable that no great departure from the general practice of winding at British collieries will be necessary in shafts of such depths as are likely to be sunk. The more difficult problem in local mining will be the heavy dip-haulage arrangements which will then be necessary to reach the deeper mines, in positions where deeper shafts are not possible. Already, I believe, there exist instances in this district of large outputs being brought up inclines nearly a mile in length at a gradient of 1 in 4, in which case the rope-question becomes almost as vital a one as in winding. So much has, however, of late been done by the extension of electricity in mining that there can be little doubt that this problem will be economically solved.

Two main, and perhaps more immediate, difficulties appear to affect this question of the development of the deeper mines of this district: (1) the question of temperature, and (2) the commercial one. On the former question much very valuable evidence, some of which was gathered in our own district, was given by Mr. Henry Bramall before the Royal Commission on Coal-supplies, and it was then stated that coal was being mined at Pendleton colliery at a depth of 3,483 feet from the surface with the temperature of air at 92½° Fahr., where no great inconvenience was felt by the men employed.* The limit of temperature at which labour can be carried on effectually is a variable one, depending considerably on hygrometric conditions.

Other conditions also must affect this limit in underground work, such, for example, as the thickness of the seam, which will materially influence the exertion required in such operations as loading. But assuming, as has been variously stated, that 98° Fahr. is not an impossible temperature for effective labour, it is possible that such a temperature will be reached in the development of deeper mines in North Staffordshire. No practical suggestions have ever been made for the reduction of the underground temperatures other than by ventilation, and the question of how far ventilation can reduce the temperature becomes of serious importance in the deeper mines. Mr. John Gerrard, H.M. Inspector of Mines, communicated, in 1904, to the same Commission a very interesting account of experimental mining at great depths which had been carried out at the Produits colliery, Mons, Belgium; where he had observed men working in a temperature gradually rising in the workings to 103° Fahr., in a dry, brisk ventilation, in a seam about 3 feet thick, the depth of the shaft being 3,773 feet.† The miners, it was stated, did not suffer distress, nor was there very marked perspiration. This is probably the greatest depth to which coal-mining has yet been carried. The rock-temperature at this point was 113° Fahr. and it was thought that the ventilation had reduced the temperature approximately by 20° Fahr. It does not seem, however, that, from an example of this sort, any definite con-

* *First Report of the Royal Commission on Coal-supplies*, 1903 [Cd. 1725], vol. ii., minutes of evidence and appendix, page 11.

† *Final Report of the Royal Commission on Coal-supplies*, 1905 [Cd. 2362], part x., minutes of evidence, page 354.

clusions can be drawn as to the possible reductions in temperature by ventilation in working-places, when mining is not being carried out from a commercial standpoint: only thirty-three men were getting coal out of 220 employed in all in the mine, and such an experiment hardly reproduces the conditions of working which will obtain in a deep mine with its necessarily large output. In my own experience, in this district, at a depth of 2,958 feet, probably at present the deepest working in the district, the temperature of the seam, as ascertained in a narrow heading at a distance of 3,300 feet from the shaft, was 94° Fahr., whilst the temperature of the air in the heading was 81¼° Fahr., with about 3,000 feet of air passing per minute. This shows in this case a reduction of temperature of 12¾° Fahr. But in a longwall-face, upon which eighty-two men were employed in the same seam at a depth of 2,490 feet, the temperature of the coal was 85° Fahr., while the temperature of the air was 82° Fahr. at a point where 14,000 cubic feet of air was passing, shewing a reduction of only 3° Fahr. The difference of temperature in the longwall-face between working-hours and during the week-end, when all men and lights were absent, and consequently the leakage of air reduced, was about 1° Fahr., and the temperature of the air at the surface was 61° Fahr. It is, I think, possible that the reduction of temperature which may be obtained by ventilation will in deeper workings be greatly influenced by the quantity of mineral exposed in fresh faces each day. The deeper pits must inevitably have large outputs, and it is difficult to think that the reduction of temperature of 20° Fahr. noted in the Produits colliery can be general, or can be obtained in actual work in this country. One conclusion, however, may be drawn from this, namely, that, as workings become deeper, it will be necessary to have smaller ventilating-districts than has been the case in extensive English collieries, so as to reduce the amount of freshly-exposed face swept by each current. Deeper mines will also undoubtedly involve very rigid attention to the question of leakage of the ventilation-current, and probably will ultimately necessitate that this point should be under the especial care of a properly-qualified official, to whose requirements many other considerations will have to be subordinated. The instance to which I have referred of a temperature of 94° Fahr. of the strata at 2,958 feet gives a rise of

temperature of 1° Fahr. for each 66 feet in depth, assuming a constant temperature of 50° Fahr. at a depth of 50 feet. Assuming that a reduction in temperature of 10° Fahr. by means of ventilation may be obtained, then the temperature of 98° Fahr. would not be reached in the atmosphere of the working-places until a depth of 3,878 feet was attained. In the case of the Produits colliery, however, it was found that with a brisk, dry ventilation, men were at work in a temperature of 103° Fahr.; and we may therefore conclude that, so far as the present developments of our local coal-field show, there will be no overwhelming difficulty with regard to the rise in temperature in working the mines to a depth of 4,000 feet, provided that our present means of ventilation are efficiently carried out. It is, however, quite possible that the method of development of deeper mines, whether it is effected by shallower shafts having considerable areas to the dip or by deeper shafts working extensively to the rise, will have considerable bearing upon this point. In the high temperature obtained at Produits colliery, the ventilation passed down a vertical shaft 3,773 feet deep to the lowest level, and therefore past that portion of the strata of the mine which was at the highest temperature, before reaching the working-places. At the deep workings at the Pendleton collieries, in Lancashire, where at a depth of 3,483 feet, or probably not more than 150 feet shallower than the site of the Belgian observation, the temperature of the air was 92½° Fahr. (or 10½° Fahr. less), and the ventilation was taken down a shaft 1,545 feet before reaching workings which had been developed by the removal of successive lower stages of the seam. Such a method of development, by following the seam, would be, however, contrary to the continental practice, and no doubt in some of the highly-contorted seams that exist in Belgium would be impracticable. It would be an interesting and not an impossible comparison, however, to obtain in this district the temperatures at two collieries working the same seam, one of which has developed the seam from a depth of 2,400 feet to 1,500 feet, and the other which has proceeded by removing successive breadths of the seam from 1,500 to 2,400 feet. Having regard to the comparatively-high temperatures which will in the future obtain in the deeper mines of the district, the conclusions of the Royal Commission now sitting with regard to the proposed treatment of coal-dust in

mines will be awaited with some anxiety by the members of this Institute. Any extensive application of water, such as has been suggested occasionally, which in a hot pit would tend to produce the humid tropical atmosphere that we are told fosters the germ of that terrible disease, miner's anæmia, would be unfortunate in the extreme.

The commercial aspect of deep mining is one that, of course, can only be referred to in a very general manner. The opening up and working of the deeper mines of this district will only take place upon a reasonable expectation of a return on the very large capital which will be required, and the prospect must generally be based on past experience of mining enterprises of the district. It has been stated by coal-owners on more than one occasion at meetings of this Institute that the return on the capital invested in local coal-mines has been totally inadequate to encourage them to proceed with further development, and the unfortunate financial history of no inconsiderable number of mining enterprises in the district is common knowledge. Of course, in so speculative an industry as mining, there are exceptions, some of them of quite brilliant character; but it must be admitted that in the past the instances in which a local mining venture has been of a satisfactorily remunerative nature have hardly been so conspicuous as those of an opposite character. Situated as the district geographically is, with a comparatively small local consumption, at a considerable distance from a port or any other large centre of consumption, it is natural that so long as the production of cheap and suitable fuels of neighbouring, but more favourably situated, districts can be maintained, the coal-industry of North Staffordshire will be handicapped. It is necessary, therefore, to regard the position of our neighbours, as compared with ourselves, for continuing to produce fuels in the future as suitable, cheap, and in proportionately equal quantities. Some light may be said to be thrown on this aspect by the estimate of the available coal-resources of the United Kingdom which accompanied the Report of the Royal Commission on Coal-supplies. In this estimate the net available tons remaining unworked in our own and adjacent districts, down to 4,000 feet in depth, are stated to be as follows:—*

* *Final Report of the Royal Commission on Coal-supplies*, 1905 [Cd. 2353], part i., general report, page 25.

		Tons.
North Staffordshire	... ...	4,368,050,347
Lancashire	... ...	4,238,507,727
North Wales	... ...	1,736,467,829
South Staffordshire	... ...	1,415,448,072
Shropshire	... ...	320 993,699
Cheshire ...	... ...	291,832,271

From this table it will be seen that the resources of this district are stated to be greater than any of the districts in our immediate vicinity with whom we enter into most direct competition. It is interesting to compare these figures with the annual outputs. In 1906, the outputs of coal are returned in the Government reports as follows:—*

		Tons.	Tons.
North Staffordshire	... .		6,215,647
West Lancashire	... ...	13,217,076	
North and East Lancashire		11,639,906	
			24,856,982
North Wales	... ...		3,169,994
South Staffordshire ...	... .		7,217,397
Shropshire	... ...		799,384
Cheshire	... ...		359,632

From these figures it will be seen that the neighbouring county of Lancashire, with an output of coal amounting to nearly four times that of North Staffordshire, has a reserve of coal-supplies slightly less than our own district; and that, while the proportion of yearly output to available coal-resources is in North Staffordshire as 1 is to 703, in Lancashire it is only as 1 is to 175; in North Wales as 1 is to 548; in South Staffordshire as 1 is to 196; in Shropshire as 1 is to 402; and in the small district of Cheshire as 1 is to 811.

Further, the proportion of the net available resources contained in seams of 2 feet and upwards in thickness in the same counties is as follows:—

		Per cent.
North Staffordshire	... ...	95·6
Lancashire	... ...	86·2
North Wales	... ...	89·5
South Staffordshire	...	90·5
Shropshire	... ...	83·7
Cheshire ...	... ...	82·0

It will thus be seen that this district stands well in front of its immediate neighbours, not only in the estimated available resources of its coal-supplies, but particularly

* *Mines and Quarries: General Report and Statistics*, 1906 [Cd. 3774], page 162.

in comparison with the annual rate at which at present those coal-supplies are being exhausted. Although the quantities of coal remaining are still very considerable in each district, yet it may be inferred that the time will not be long in coming, if it has not already arrived, when that district which possesses the greater resources of thicker seams must come to the aid of those less fortunately situated in this respect. In this manner it may be presumed that the disadvantage of geographical situation, and of the physical difficulties in the working of the heavily-inclined seams, will at no distant date be counterbalanced by an increasing demand for the superior house-coals of the district over a more extended area; and that accordingly the coal-industry of North Staffordshire may look forward to a more prosperous future and a greater rate of expansion than it has hitherto experienced.

Gentlemen, I have endeavoured to dwell briefly upon some of the features of the mining industry which particularly affect our own district, and which, so far as they affect the future development of North Staffordshire mining, are of vital importance to the members of this Institute. I am afraid that I have been able to throw very little new light upon these points, but, in recalling such matters to our recollection, we may possibly arrive at some better estimate and appreciation of our position in the industry in which we are engaged.

Mr. E. B. Wain (Whitfield collieries), in proposing a vote of thanks to the President for his extremely interesting and practical Address, said that in the many years during which he had had the pleasure and privilege of attending the annual general meetings, there had not been delivered a more thoroughly practical, useful, and helpful Address than that they had heard that day. The members were proud that their Institute had produced a gentleman who had risen from the status of a student, and who could now give them thoroughly sound advice. The President had raised many points of extreme importance; but he thought that he had touched too lightly—perhaps wisely so—on the all-important labour question. No one in North Staffordshire was better qualified to speak of the facts and conditions of coal-mining

at great depths than Mr. Hyslop, and he was sure that the members heartily wished him success, not only as President of the Institute, but also in the undertaking that he had carried through recently. The questions of temperature were matters of considerable importance, and he hoped, although they could not discuss the Presidential Address, that some portion of that information would be embodied in a paper, in order that the matter could be thoroughly discussed. And last, but not least, he thought that the President had helped them to realize that, after all, North Staffordshire—a small and comparatively unimportant colliery district—had in the future a much better prospect before it. When the members realized that North Staffordshire possessed a reserve of minerals equally large as that of the great Lancashire coal-field, certainly some of the younger members would feel that they had a good and prosperous time in front of them.

Mr. John Newton (Wolstanton), in seconding the vote of thanks to the President, said that there could be no doubt that, within a few years, there would be a great development in the working of collieries; and one was inclined to wonder, when one looked around and saw the enormous strides that had been made in the last thirty or forty years, what would be the next step in scientific progress. There was, for instance, the prevention of smoke, and he hoped that in the next few years they might be able to walk through the streets of the Potteries or Newcastle-upon-Tyne, and see a perfectly clear atmosphere.

The resolution of thanks was carried unanimously.

Mr. J. T. Stobbs (Basford) moved a vote of thanks to the retiring members of the Council for their services to the Institute during the past year. Certain members retired by rule, and he thought that thanks should be given to them for the help and time which they had given to the Institute.

Mr. John Newton seconded the vote of thanks, which was agreed to.

THE NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT, DECEMBER 9TH, 1907.

MR. G. P. HYSLOP, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The PRESIDENT (Mr. G. P. Hyslop) referred to the great loss that Mr. W. N. Atkinson, a Past-President of the Institute, had sustained recently by the death of his wife.

Mr. E. B. WAIN (Whitfield collieries) proposed the following resolution:—

"That this meeting desires to express its deep sympathy with Mr. W. N. Atkinson in his recent bereavement."

Mr. R. H. COLE seconded the resolution, which was carried in silence.

DEATH OF MR. M. WALTON BROWN.

Mr. A. M. HENSHAW (Talke) said that everyone who had been connected with The Institution of Mining Engineers would appreciate the services of Mr. M. Walton Brown, who for many years had performed the onerous secretarial duties, and to whom, to a large extent, much of the success of the Institution, and the high character of the *Transactions*, was due. He asked them, by rising, to express their sympathy and condolence with the family of the deceased gentleman in the following terms:—

"This meeting desires to place on record its deep regret at the sudden death of Mr. Walton Brown, Secretary of The Institution of Mining Engineers, and wishes to convey a vote of tender sympathy with Mrs. Brown and family in their bereavement."

The resolution was carried in silence.

PRIZES FOR ASSOCIATES AND STUDENTS.

The PRESIDENT (Mr. G. P. Hyslop) announced that Messrs. W. N. Atkinson and A. M. Henshaw had generously returned to the Council the amount awarded to them as a prize for their paper on "The Courrières Explosion;"* and desired that the amount should be devoted to two prizes for the best papers contributed to the Institute by an associate or student of the Institute, a member of the Mining Students' Association, or a member of the County Council Mining Classes, during the year ending, July, 1908; the award, of the value of £4 4s., to be at the discretion of the Committee of Selection on the paper submitted.

Mr. W. CHARLTON (County Council Mining Lecturer for South Staffordshire) gave an interesting lecture on "Some Methods of Working the Thick Coal of South Staffordshire," illustrated by a large assortment of unique lantern-slides.

Mr. J. C. CADMAN proposed, and Mr. H. JOHNSTONE seconded, a vote of thanks to Mr. Charlton for his lecture.

Mr. CHARLTON acknowledged the vote of thanks.

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* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 439.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
NOVEMBER 12TH, 1907.

MR. JOHN ASHWORTH, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected, having been previously nominated:—

ASSOCIATE MEMBER—
Mr. GEORGE EDWARD LOMAX, Fern Hill, Huyton, Liverpool.

STUDENT—
Mr. THEODORE HODSON NUTTALL, Longport, Freshfield, near Liverpool.

MEMBER, NON-FEDERATED—
Mr. BENJAMIN PALIN DOBSON, South Bank, Heaton, Bolton, Lancashire.

Mr. JOHN ASHWORTH delivered the following "Presidential Address":—

PRESIDENTIAL ADDRESS.

By JOHN ASHWORTH.

My first and pleasant duty is to thank you for the honour which you have conferred upon me in electing me President of your Society. I fully appreciate this honour, and it will be my endeavour, with your co-operation, to advance the interests of the Society in every way during my term of office.

This Society was originally a geological society, and it is only of late years that the mineralogist has been admitted into its fold. This is as it should be, for you cannot wisely divide such closely-allied subjects.

Sir Archibald Geikie says, in his Address at the Centenary Meeting of the London Geological Society:—*

"It has been said that the geologist ought never to forget that the mineralogist was his father. The study of minerals certainly preceded that of rocks; and it should always be remembered that the early mineralogists were in reality the first geologists, by whom the foundations of the petrographical divisions of geology were laid. But, if the geologist is to own the mineralogist as his father, he must surely acknowledge the miner to be his grandfather.

"For many centuries, and long before the use of scientific mineralogy, most of the current knowledge of the nature and disposition of the minerals and rocks of the earth's crust sprang out of the labours of those engaged in mining operations. It was the business of those men to make themselves practically acquainted with the subject, so far, at least, as regarded the facts that had to be attended to in the sinking and working of mines.

"As a rule, however, they did not trouble themselves with explanations or speculations as to the origin of the rocks with which they had to deal, and when they did so they usually attained to no greater measure of success than other theorists before them. But when the miners established mining schools for the training of those who were to follow their craft, they took an important forward step in paving the way for the creation of a sound geology."

I think, gentlemen, that we can endorse this statement, and the more readily because in a later portion of his Address Sir Archibald Geikie made reference to the admirable assistance given to geologists by the mining institutions, which were originally designed for the practical miner, but eventually developed into training colleges for the geologists.

* *Times*, September 27th, 1907, page 14.

It would ill become me to address you on the vast subject of geology, for this Society has been honoured by many noted geologists, of whom I may mention Mr. Joseph Dickinson, who has been a member of this Society for over 50 years, and has done yeoman service in this branch of knowledge, not only for our members but for the country. We have also Prof. William Boyd Dawkins, who has laboured in the past, and is still an active member amongst us, thus forming the link which binds the early and speculative work of the Society with the more practical and accurate operations of to-day. To the late Mr. Mark Stirrup, whose death took place so recently as June last, we owe also a great debt for the enrichment of the *Transactions* with extracts and original contributions of a very high standard, apart from his labours as Honorary Secretary for a lengthy period. My Address, therefore, will be rather as a mining man than as a geologist.

The various matters relating to the regulations and working of mines are too familiar to you to require anything in the nature of a review from me. We can still congratulate ourselves that this country continues to hold the first place in respect of regulations for the safe working of mines. This point was conceded at the recent Miners' Congress at Salzburg. I am, however, afraid that the proposal of the Belgian representative at that Congress, namely, that coal-production should be regulated by international laws, will not prove a very workable proposition, although it secured the moral support of most of the delegates.

It is also worthy of note that His Majesty King Edward has created a new medal for gallantry in mines and quarries. The warrant states that the King is " desirous of distinguishing by some mark of our royal favour the many heroic acts performed by miners and quarrymen and others who endanger their own lives in saving or endeavouring to save the lives of others from perils in mines or quarries within our dominions and in territories under our protection or jurisdicton." The new medal will be of two classes, to be designated (1) "The Edward Medal of the First Class," in silver, and (2) " The Edward Medal of the Second Class," in bronze. This indicates his Majesty's great interest in the efforts made to reduce the danger and the death-roll in collieries, and such encouragement has been applauded and approved by everyone connected with mining.

Mining men in this country are in many cases looking anxiously for the report of the Royal Commission now taking evidence on the safety of mines. The subjects of rescue-apparatus and the best treatment of coal-dust continue to excite the keenest interest, and a preliminary report on the first subject has already been issued. It is to be feared that far too much is expected to result from rescue-apparatus, the cheapest of which is very expensive. Up to now, there does not appear to be more that one instance of the saving of the life of a miner by such an apparatus, and this occurred in an Australian mine, at Bonnieville, where a miner, having been imprisoned by an inrush of torrential rain, was kept alive for nine days through the daring and cool bravery of two divers, who made periodical visits with food and eventually rescued him, very little the worse for his imprisonment. Doubtless, rescue-apparatus will be found of great advantage in the case of gob-fires and other similar occurrences underground, but it seems curious that a simple. inexpensive apparatus called the Denayrouze, which was introduced into the country many years ago, was not brought before the present Royal Commission.

On the general subject of rescue-work in mines, it seems to me that a great deal more might be done by the Home Office in apportioning a considerable sum of money per annum for scientific investigations, which would materially tend to increase the safety of the persons engaged in our great coal-industry.

With respect to the attitude of capital and labour, I think you will have noticed that there is a strong desire growing up amongst all sections of the community that courts of arbitration should be formed to settle industrial disputes, rather than to be obliged to resort to the barbarous practice of strikes. This point was very clearly brought out in Mr. Enoch Edwards's speech at Southport,* when he strongly suggested the settlement of disputes by means of reason and conciliation rather than striking first and adopting reason and conciliation afterwards.

The Miners' Eight-hours' Day Bill will probably become law during the next session, and although the conclusions of the Parliamentary Committee make light of the assumed loss on a production of 25,783,000 tons, calculated on the output for 1906, it is not denied that considerable loss will inevitably follow the

* *Manchester Guardian*, October 9th, 1907.

adoption of such a measure; and many other expedients are suggested for mitigating the effects of the proposed reduction in the time underground. The employer's remedy lies apparently in the extended use of labour-saving machinery, such as coal-cutting machines and conveyors, and in the improved mechanical equipment of the mines generally. The Committee admit that certain temporary and permanent relaxations of the rigid rule might be found necessary in the interest of safe working, and that the conditions are variable to such an extent that special regulations would be required for certain districts.

From many of these conclusions it is clear that the operation of law will not remove all the intricacies of the existing systems, and a hard-and-fast limit of working-time will be found detrimental to the industry, both from the point of view of the employer and that of the employed. And, further, is there not some reason in all these considerations for the feeling that many of us have, that these processes of restriction—this law-pervading atmosphere dominating our industrial and social life—are destroying in our race and nationality that individualism, that spirit of self-reliance and of self-restraint which, beyond doubt, have had much to do with the industrial as well as the national development of England.

We move in days of big combines and trusts, where everything is done by concerted moves, and where, except in a few brilliant instances, personality is submerged and operations are performed mechanically. The danger which I apprehend is loss of character by the reduction of the personal element in our undertakings, and if we look upon our national industries not merely as means whereby men may rapidly and selfishly accumulate wealth, but also as means of intercommunication of sympathies and goodfellowship between capital and labour (which, after all, should be one of the principal motives of our commercial aims and pursuits), the danger to which I refer becomes a real one, and one to which philanthropic capitalists might well direct attention.

We cannot be unmindful of the service rendered by the workers in the days when legal ties and binding clauses were almost, if not quite, unknown, and when labour was performed from a sense of duty sufficiently strong to keep the worker at his post and assist in the wonderful development that has characterized modern English history.

Let us for a moment reflect on the great and rapid change made in England by the coal-miner. Has he not completely revolutionized our land, and turned a large part of an agricultural country into a huge workshop? Only one hundred and fifty years ago, Lancashire was the poorest county in England and the most sparsely populated. To-day, if you take an area of 50 miles round this room, you enclose a population more dense than in any other part of the world. You may liken it to one big workshop built on a coal-hole. The miner has mainly effected this change.

This change has brought with it many problems, and one is tempted to ask whether some of us have not lingered too long on the slopes of the Pennine Chain? Is there any outlet for this congested population? Gentlemen, I venture to think that there is; it is not in Old England, but in a New England beyond the sea. A land that covers one-fifteenth of that of the world, and yet has not a total population of London to-day. I refer to Canada.

It seems to me that the miner would do well to turn his attention more assiduously to this vast Dominion, for in my opinion it will prove to be one of the most solid and enduring jewels in the British crown. It is a happy omen that the 1908 summer meeting of the Canadian Mining Institute is to be held, to some extent, under Canadian Government auspices, and promises to be a most important one and worthy of the best representation from this country. For these reasons I shall for a short time take your thoughts away from the mother-country to her offspring across the sea, feeling sure that it is for us, and especially the younger amongst us, whose field of observation is widening out, to mark, learn, and inwardly digest every phase of mining activity, every fresh means adopted to meet a particular contingency, and to apply the beneficial result of our observations to the work in hand. In order to acquire this experience, it is absolutely necessary that fresh fields should be sought and appropriated; the situation is one which should have a peculiar attraction for the young mining engineer or colliery manager whose steps should be directed towards new fields where his energy can find full development. Could he have better prospects than in Canada—a land that can feed an empire? A land that is the best watered, and has the best fisheries in the world; a land that extends from latitude 42 (in a line with Rome) until it is lost in the land of the Midnight Sun.

After every visit I have paid to this vast dominion, I have returned more impressed with its possibilities, and if I can only arouse your interest, I feel sure that you will agree with me that Canada is the country of the future for our surplus population, and that the Lancashire man, especially the miner, will do well to give it his serious attention.

The miner was ever the pioneer in the industrial world, and I therefore venture to bring before your notice some points bearing upon the potential resources of this country. For the sake of brevity I propose to group Nova Scotia, New Brunswick, and Prince Edward Island together, as they are known as "Acadia," or the "Land of Plenty."

Of all the numerous British Colonies, this region presents the strongest family likeness to the mother country, not only in the singular variety of its resources, but also in its proximity to the markets of the world.

Gold, which excels in purity that of Australia and California, is found here. It is here that we have unequalled fisheries, safe harbours, extensive coal-fields near the water's edge, and, above all, a position almost midway on the very highway between the old and the Pacific side of the new world. And I am one of those who believe that Acadia will inherit a full share of that greatness which Britain in her old age must resign.

Though it cannot be said to have yet attained the prosperity predicted for it, this region is to-day by no means an insignificant contributor to Canadian wealth, for of the total number of miners engaged in Canada, 42 per cent. find occupation in Nova Scotia.

Coal is the staple mineral, and the Cape Breton, Cumberland, and Pictou fields provide a fair proportion of the whole output. In Cape Breton, coal is obtained in great quantity from the Sydney and Inverness coal-fields. The Sydney coal-field was the first exploited, operations dating from the year 1785.

In 1863, the output of coal for Cape Breton was 214,812 tons: to-day it is over four million tons. The other fields in this district of Acadia are responsible for a little more than a million tons, or a quarter of the Cape Breton output.

The Coal-measures of the Cumberland area crop out on the sea-shore, and have been worked extensively at the Joggins Mines, where a seam of about 6 feet of coal has yielded an annual output of about 80,000 tons.

The Pictou coal-field, opened up in 1827 by the General Mining Association, is about 11 miles long, 3 miles wide at its broadest part, and covers an area of about 22 square miles. Its structure presents many interesting features, and a few problems, some of which are: the remarkable thickness of the seams (in some cases 40 feet); the extensive deposits of black and brown shale; the marked changes in these deposits noted at comparatively short distances; the nature of the dip, ever changing, but always considerable; and the numerous large and small faults intersecting the field at many points.

The three coal-producing districts of this field are the Albion, the Westville, and the Yale. The coals vary in character, but are all of the bituminous coking variety. Some tested at the Gaslight and Coke Company's Works, London, have yielded 10,450 cubic feet of gas, of 15 candlepower, per ton. The slack is valuable for blacksmith's purposes.

The fiery nature of the seams has necessitated the use of fans of large capacity and modern construction, in place of underground furnaces. Mueseler, Marsaut, and other lamps have been in use for many years.

Quite recently the local papers announced that the Dominion Coal Company, whose annual output is about 3½ million tons, had a representative in this country busily seeking to enlist an army of 2,000 miners for their collieries in Nova Scotia. Lancashire, Yorkshire, and Staffordshire men are preferred, it is said, as being more accustomed to the longwall system, which is the method of working adopted in this part of the Dominion.

The area of gold-measures in Nova Scotia has been estimated by various authorities to cover from 5,000 to 7,000 square miles, or from one-fifth to one-third of the area of the province, yet the actual area from which the gold thus far obtained has been won is less than 40 square miles.

In gold, as in other things, this region has not yet realized the great hopes entertained some years back, when it was thought that the saddleback reefs, which bore a close resemblance to the famous Bendigo saddlebacks, would turn out similarly successful in the process of extraction. Still, there are many who feel that gold-mining has here a great future before it; and the field is being thoroughly tested, in order to determine the future course of action.

Gypsum is plentiful in Acadia, 435,805 tons having been produced in 1905.

Entering the gulf of St. Lawrence, we reach Quebec with its rocky fortress, and at once come into touch with that great highway of the world, the Canadian Pacific Railway, which extends from ocean to ocean, a distance of 3,077 miles, traversing in its course the rich St. Lawrence valley, the prairie uplands, and the metalliferous Rocky Mountains to Vancouver. The Grand Trunk Pacific Railway, another great highway, is in course of construction, taking a direction to the north of the Canadian Pacific line, and will extend from Halifax to Prince Rupert on the Pacific Ocean, passing through and opening up many mineralized districts.

The Province of Quebec is a most picturesque land of green hills, forests, rivers, lakes, and waterfalls, with the pretty villages and old-fashioned churches and homesteads of the French Canadians, dotted here and there with luxurious orchards, and sleek kine grazing in the rich pastures; everything in this province of 350,000 square miles is agreeable to the view of the traveller. Here agriculture and the lumber-trade loom large in the people's industry, but there is also a steadily increasing mineral-production, which in the year 1905 employed 5,017 persons, 1,650 of whom were engaged in the mining of asbestos. This mineral occurs in considerable quantities, in the form of small veins in intrusive serpentine, in the eastern townships of this province, and also at various points north of Ottawa, in association with serpentine rocks of the Laurentian formation.

In addition to asbestos—the most important of Quebec's minerals—cement-stone, copper-ore, graphite, and mica are obtained in considerable quantities.

Passing on to the Province of Ontario, which is known as the "Garden of Canada," we behold what is in many respects a wonderful province. It extends for 1,000 miles from east to west, is considerably larger than the whole of Germany, has innumerable lakes connected by ship-canals, a multitude of rivers, tremendous water-power plants, a rich soil, an equable climate, and great mineral resources, opening a boundless field of operation for the prospector. The nickeliferous deposits near Sudbury are the richest in the world, and the output of this mineral for 1905 was about £4,500,000 market-value.

Extensive iron-ore deposits are worked at the Helen mine, Michipicoten, along the line of the Kingston and Pembroke and Central Ontario Railway, and smelted at Sault Ste. Marie furnace and steel-works, and at Port Arthur ironworks. Twenty miles north of the famous nickel-district, iron-ore is also found in the Moose Mountains (rocks of Keewatin age). Drilling and blasting are here in full operation, and a railway only is required to make the Canadian iron-ore certain of admittance into all markets. The proportion of iron in the ore is 60 per cent. It is reported that a mineral smelting-plant is to be erected near Toronto, which will provide employment for 15,000 men, treating 1,400 tons of ore daily. No coal had been discovered in this province until quite recently, when lignitic coal was found near Lake Abittibi.

North of Sudbury lies the recently developed rich silver-mining area of Cobalt, which is confined within the small compass of 12 square miles, 5½ miles from south-west to south-east, and only 3 miles across at its broadest part. At the Larose mine, considerably more than 300 feet of good ore has been proved, and a much greater depth of equally rich ore is anticipated.

Natural gas and petroleum are found in Southern Ontario, the annual value of the former exceeding £5,000,000 and of the latter £190,000. At Goderich, a seam of rock-salt of very fine quality, 30 feet thick, is worked, and at the Jarnion mine, Madoc, Hastings county, iron pyrites has been discovered.

A comparatively new industry in Canada, and one allied to mining, is that of clay-working. In the year 1887, no one appeared to realize the importance of this province as a producer of pressed brick, and bricks were imported from Ohio, in the building of a large Toronto bank, at a cost of £8 per thousand. To-day they are manufactured in the province at a price considerably lower than that mentioned, and the importance of this industry is further evidenced by the announcement of a new Canadian organization under the name of the Canadian Clay-products Manufacturers. A valuable handbook on the Clay Industry has recently been published by the Ontario Bureau of Mines.

Further encouragement to mining in Ontario is given in the arrangement of summer classes in connection with the mining colleges of McGill, Toronto, and Kingston: the students who are

sent out into the interior to study geology are each provided with samples of the ores that are likely to be found in the various districts.

Travelling westward, we reach the great prairie Province of Manitoba, the indications of the development of which are best given in the figures of population, which, during the last 36 years, has increased twenty-fold, and now stands at something like 360,000. Winnipeg, the midway emporium of the Dominion and the capital of Manitoba, in 1871 had a population of 100; to-day its population exceeds 100,000.

It may be of interest to note that Mr. J. Obed-Smith, the Commissioner of Immigration, is a Lancashire man, and is responsible for all immigrants passing through to the west.

Though primarily the "granary" of the Empire, Manitoba and the North-West Provinces are not bereft of mineral wealth, as they are underlain by rich stores of lignite, which is a useful fuel for the cities and scattered farming population.

Saskatchewan and Alberta, the two new provinces, each have an area of more than twice the size of the British Isles, but only a very small portion of their rich arable land is as yet under cultivation; nevertheless, the population had increased from a few hundreds in 1890 to nearly 500,000 in 1906.

In Alberta there are enormous deposits of lignitic coal. The principal developments of anthracitic and bituminous coals have been made in the neighbourhood of Banff, Frank, and Coleman, and to a similar extent between Calgary and Edmonton.

Considerable deposits of iron-ore recently discovered in Alberta, suggest an industrial as well as an agricultural future for this district. In Southern Saskatchewan, at the northern fork of Willow Creek, there has been found a deposit of ore containing 5 per cent. of manganese, which will doubtless be profitably worked by some enterprising capitalist.

Natural gas is found in many places, the principal supply at present being found at Medicine Hat. After 14 years' continuous use, the volume of gas has shown no shrinkage, and the supply appears to be very far from exhaustion. The town is supplied with light and fuel from this source at a cost of 8½d. per 1,000 feet.

At Lethbridge colliery, in the Belly-river coal-fields, Alberta, a 5½ feet seam, with a fire-clay parting, is worked in a mine

equipped for the production of 1,000 tons per day, coal-cutting machines and endless-rope haulage being employed. Some 60 miles of railway are owned by the company, the line extending from Lethbridge to Coutts. Coal is delivered in Edmonton at 5s. and 6s. per ton, and along the steep banks of the North Saskatchewan it can be obtained open-cast without being actually mined.

Leaving the prairie provinces, we approach British Columbia, the region of the Rockies, the backbone of Canada, as the Pennine Range is of England. This region is by far the most important part of Canada as regards mining. The surface, which extends for 400 miles across a confused mass of high ranges and uplands, has been little more than scratched, in a mining sense. Its economic development seems only just to have made a systematic commencement, but great advances are now being made. Last year showed a production valued at about £5,000,000. The annual output during the last ten years has been more than doubled, and one company—the Granby Mining, Smelting, and Power Company, Limited, the largest and most important, with a capital of £10,000,000, over £3,000,000 of which is issued stock, and held by Americans who control the undertaking—produced 645,000 tons of ore out of a total output of 930,000 tons.

Though not as yet a large producer of iron-ore, British Columbia has proved deposits at Cherry Bluff, Kamloops, and Texanda Island.

Copper, gold, coal, and lead, in the order named, are the most important minerals, the output for 1905 being valued at £1,657,713, £1,055,808, £910,182, and £533,515 respectively.

Of the total lead-output of the Dominion, 98 per cent. is produced by British Columbia, the output being shared largely by the Fort Steele and Slocan districts. In 1905, more than 56½ million pounds of lead-ore were obtained, the value being something like £480,000. The Boundary district is responsible for much of this mineral yield; and, having had an opportunity of visiting the district, I must say that for the variety and value of its ores it will be difficult to find an equal.

The coal-output of British Columbia during 1906 was restricted to the Crow's Nest Pass and the collieries on Vancouver Island. Coke for smelting is in increasing demand, and, owing to the scarcity of labour and the urgent call for coal, the supply

of coke has been inadequate, as a consequence of which a cargo of 3,000 tons was imported from Australia during 1906 by the Crofton smelter.

All this proves that development-work can be very materially and profitably increased by the influx of more capital and additional labour. Thus the Canadian Pacific Railway Company is spending £300,000 in opening up collieries in the Crow's Nest district, and is also a great producer of anthracite at Bankhead, Banff, Alberta.

At Princeton, a seam of coal, 18 feet thick, has been found, 49 feet from the surface; and, on the western edge, a bore-hole, 863 feet deep, has disclosed seventeen seams, aggregating 50½ feet of good coal.

In the Telqua district, a recent telegram states that very rich deposits of coal have been located, and as the projected line of the Grand Trunk Pacific Railway runs through the heart of this new field, some speedy development-work may be expected.

Some novel features have been introduced by the British Columbia Board of Examiners in the rules for the examinations for the coal-mine officials' certificates. For example, every man is to be submitted to a sight test, to ascertain his capacity to see a cap of fire-damp in a safety-lamp, and each candidate will have to pass this test successfully. The Board of Examiners have also concluded that a man ought not to be expected to memorize a bookful of formulæ, and if he can work out the problem when the formula is set before him, he will thereby satisfactorily demonstrate his capability. Holders of first-class managers' certificates must be British subjects. In addition to the examinations for officials for the first, second, and third-class certificates, monthly examinations are held for miners, all of whom are required to hold a certificate of competency.

In and about the coastal collieries the proportion of alien labour is very great, and 774 Chinese, 86 Japanese, and 55 Indians found employment in 1906. Trouble has arisen over the influx of Japanese into Vancouver, and the feeling of the whites is very bitter against its continuance. In the Crow's Nest collieries no yellow labour is employed.

I have now taken you across the continent, from coast to coast; and, although we have rapidly examined the localities of the most important minerals, a vast amount of exceedingly

interesting information on mining progress has necessarily been omitted. The principal object of my Address is to endeavour to bring before your notice something of the immensity of the value of our Canadian possessions, with a view to impressing upon you the importance of the direct investment of British capital in Canada, instead of through the New York and other stock-exchanges, as at the present time; for the danger is that Americans will secure the command, through capital, of Canadian mining and other undertakings. If this country is to have and to keep the controlling power, it is essential that she should hold the purse-strings.

You will see, therefore, why the people of the United States of America have secured controlling interest in the Crow's Nest Pass Company. Last year they took 230,000 tons of coal against 150,000 tons sold in Canada, and 53,000 tons of coke against 134,000 sold in Canada. I think that only one colliery in Vancouver Island makes coke—about 23,000 tons in all—of which the United States of America took 8,000. Taking the Vancouver Island collieries into account, the United States took 664,000 tons against 682,000 tons taken by Canada. The export to the United States would have been still larger, if the Californians had not taken to using an increased tonnage of crude oil.

The latest news from the famous Crow's Nest district reports huge beds of coal above the railway, and the Pennsylvanian miner sees in this district—if the British speculator cannot—great beds of coal more than equalling the enormous deposits of his own State.

There was, and is, a great truth underlying the remark made by the Prince of Wales in reference to his Canadian visit, that "England must wake up," otherwise she will fail in her duty to the Dependencies.

Tables I. and II. give interesting particulars relating to the mining industry of the Canadian provinces, and the various mineralized areas are indicated on the map of the Dominion (plate vii.).

Now, gentlemen, it remains for me to thank you for having listened so patiently to the rather cursory treatment of a most important subject; but I trust that what I have said may be found of some little use, and that, as opportunities permit, mem-

TABLE I.—SHOWING AREAS, POPULATIONS, AND MINING STATISTICS OF THE CANADIAN PROVINCES FOR 1905.

Province.	Capital.	Area (square miles).	Population (1901).	Population per square mile.	Mining Population.	Mining population per 100 square miles.	Proportion of Population engaged in Mining. Percentage.	Death-Rate per 1,000 engaged in Mining.	Total Mineral Production. Dollars.	Total Mineral Production. £ Sterling.	Mineral Production per head of Mining Population £
Nova Scotia	Halifax ...	21,428	459,574	21·80	10,780	50·00	$2\frac{1}{3}$	2·00	11,507,047	2,301,409	213·48
Quebec	Montreal ...	351,873	1,648,898	4·82	5,017	1·42	$\frac{1}{3}$	0·40	4,405,975	881,195	175·64
Ontario	Toronto ...	260,862	2,182,947	9·90	11,151	4·27	$\frac{1}{2}$	0·35	18,833,292	3,766,658	337·78
British Columbia ...	Victoria ...	372,630	178,657	0·48	8,117	2·59	5	3·50	22,378,187	4,475,638	551·38
Prince Edward Island	Charlottetown	2,184	103,259	47·30	—	—	—	—			—
New Brunswick ...	Fredericton ...	27,985	331,120	11·90	—	—	—	—	559,035	111,807	—
Manitoba	Winnipeg ...	73,732	255,211	3·96	—	—	—	—	—	—	—
Alberta...	Edmonton ...	253,540									
Saskatchewan ...	Regina	250,650	211,649	0·11	—	—	—	—	11,841,634	2,368,327	—
North West Territories		2,130,690									
	Totals and Averages ...	3,745,574	5,371,315	1·48	—	—	—	—	69,525,170	13,905,034	—

Total area of Canadian lakes = 125,756 square miles approximately, or 80,483,222 acres, being one-thirtieth of the entire area of the Dominion.

bers will come forward to supplement my remarks by original papers on the various sections in which they may be specially interested.

TABLE II.—GOLD, SILVER, COPPER, LEAD AND COAL-PRODUCTION FOR 1905.

	Gold. Per cent.	Silver. Per cent.	Copper. Per cent.	Lead. Per cent.	Coal. Per cent.
North-West Territories ...	57	—	—	—	30
British Columbia	39	57	78	98	12
Nova Scotia	2	—	—	—	58
Ontario	—	40	18	2	—
Quebec	2	—	3	—	—
Other provinces	—	3	1	—	—
	100	100	100	100	100

Mr. JOSEPH DICKINSON (Pendleton), in moving a vote of thanks to the President, said that Mr. Ashworth had given them a weighty and very comprehensive Address. One must hope that the wish expressed at the beginning would be realized, and that all the members would do their best to aid him in his office and maintain the high standard that the Society had held for so many years.

Mr. JOHN UNSWORTH (Chorley), in seconding the vote of thanks, said that he had listened with the greatest attention to the President's very eloquent Address, which contained much food for reflection. There was no doubt that the Dominion of Canada was a very good field, open to all of them; and to the younger members of the Society in particular, who were looking forward to a successful career, there was something in Canada which was peculiarly attractive.

Mr. JOSEPH CRANKSHAW (London) said that he would like to say a word or two about Mexico, where there was a more equable climate, and mining operations were being carried on with great success and financial profit. The district near the Pacific Coast had been neglected, but it also presented many points of attraction. Near the coast, the climate was hot enough to enable one to dispense with clothes, while further inland they could get to the mountains and to the eternal snow-line. In addition to coal, there was a wonderful salt-deposit. The possibilities were enormous, now that mines were being opened out and lines of steamers were being started. Vessels from British Columbia brought

timber, and took back salt. Here, then, was a field for the employment of British capital. Already a good deal of Canadian capital was invested, and many of the stores were run by Canadians.

The resolution was passed unanimously.

The PRESIDENT (Mr. John Ashworth) thanked the members for their patience in listening to his Address. He was glad to see so many present at the meeting, and hoped that it was an augury of increased usefulness for the Society. It had occurred to him that interest in the Society would be increased, and its usefulness extended, if they held their meetings occasionally in other places than Manchester. They might, for example, have meetings at Leigh, at Bolton, and perhaps at Wigan and St. Helens. This was a matter which perhaps the Council would take into consideration during the session.

TATE'S IMPROVEMENT FOR SAFETY-LAMPS.

Mr. JOHN GERRARD (H.M. Inspector of Mines, Worsley) called attention to Mr. J. W. Tate's arrangement for ascertaining that gauzes are present in bonnetted safety-lamps. If the gauzes were not in the lamp, with this arrangement the light would not burn. Mr. Gerrard subjected the lamp to several tests, so as to show its effective working (figs. 1, 2, and 3).

Mr. VINCENT BRAMALL (Pendlebury) thought that a portion of the apparatus which should slide up and down freely might stick, and so prevent its perfect working.

Mr. JOHN GERRARD submitted that if the lamp were kept clean, as it ought to be, it would not stick. It seemed to him to be a very simple check with regard to the use of bonnetted lamps and gauzes. Of course, there were other arrangements, or inventions, to provide for the gauzes being in the lamps, but this seemed to him to be such a very simple one: he had tried it during the past month, and it had never failed to act. The idea was simply an extinguisher which prevented the feed of air to the lamp, and caused the flame to die out when the gauzes were not in the lamp. If the gauzes were in the lamp, they held up the disc or cap and the light would burn freely.

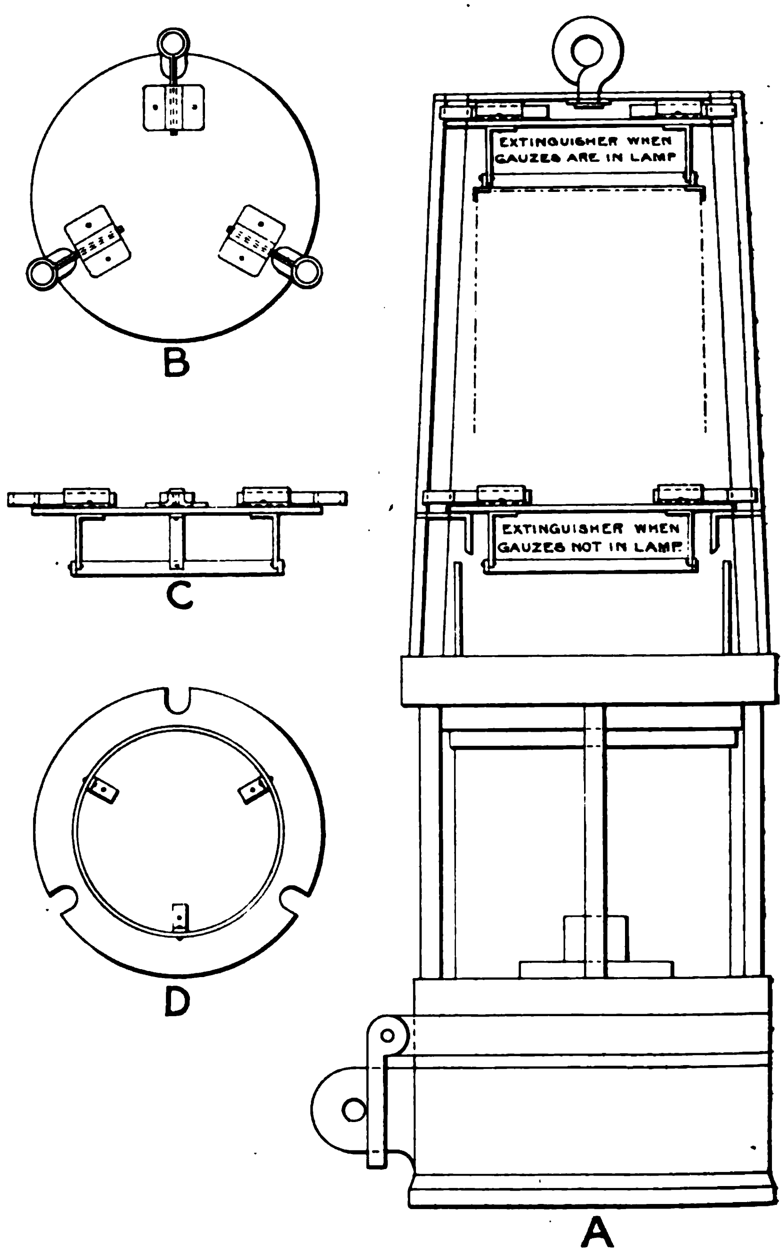

FIG. 1.—DETAILS OF TATE'S APPLIANCE FOR BONNETTED SAFETY-LAMPS: A, VIEW OF LAMP; B, PLAN OF EXTINGUISHER; C, SIDE VIEW OF EXTINGUISHER; D, UNDERSIDE VIEW OF EXTINGUISHER.

Mr. J. W. TATE (Tyldesley) said that he had used the lamp daily for a month in the mine, and it had never failed. The appliance could also be adapted to most types of existing safety-lamps; therefore a colliery manager could add this arrangement and have the lamps bonnetted, and could rest assured that before a lamp was given into the hands of anyone the gauze was present, for the light in the lamp would not burn if the gauze were omitted.

FIG. 2.—LAMP WITH TATE'S APPLIANCE HELD UP BY GAUZE.

Mr. PERCY LEE WOOD (Clifton) remarked that before taking up with a new invention, one should be satisfied that it was an improvement on other systems at present in use. While Mr. Tate's arrangement was a step in the right direction, he thought the Patterson arrangement better for several reasons, the principal one being that, with a Patterson bonnet, if either gauze were omitted it would be detected immediately; but he thought that with the Tate arrangement, if one gauze only was in the bonnet, it could not be detected. There were 2,000 lamps with Patterson gauzes at work in the pits under his charge, and he had never had any trouble with them.

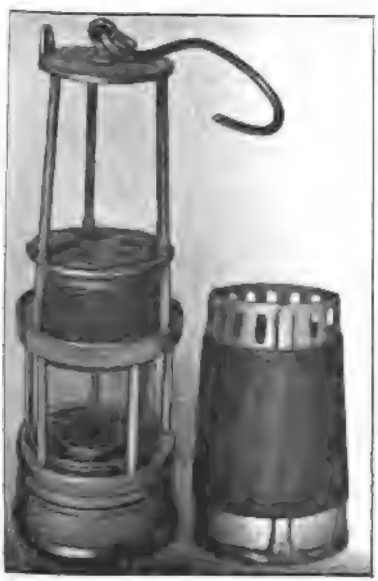

FIG. 3.—LAMP WITHOUT GAUZE.

Mr. GERRARD remarked that there might be something to be

said in favour of an invention which secured at least one gauze being in the lamp rather than none.

Mr. WILLIAM HORROBIN (Leigh) said that it was an impossibility for a miner to get into the pit without gauzes in his lamp under the system invented by Mr. Tate.

Mr. JOSEPH DICKINSON (Pendleton) said that Mr. Gerrard's profession brought him into contact with the results of so many mistakes that he naturally desired to know which was the best form of lamp for use in mines.

Mr. JOHN GERRARD (H.M. Inspector of Mines, Worsley) said that he simply brought the lamp before the members for their inspection. He did not ask them to approve of it, or adopt it, but only to look at it and see how far it excelled other forms of safety-lamps.

THE HARDMAN IMPROVED SPUNNEY-WHEEL.

Mr. JOHN GERRARD (H.M. Inspector of Mines, Worsley) next drew attention to Mr. Walter Hardman's improved spunney-wheel, an ingenious contrivance for preventing accidents through the trapping of fingers in the pulley of the ordinary spunney-wheel. It was impossible for a man to get his fingers trapped under this arrangement as the wheel was completely closed in. It was for small jig-brows, where a simple wheel with rope or chain passing through it was in use. Fig. 1 showed the brake free, and fig. 2 the brake in action.

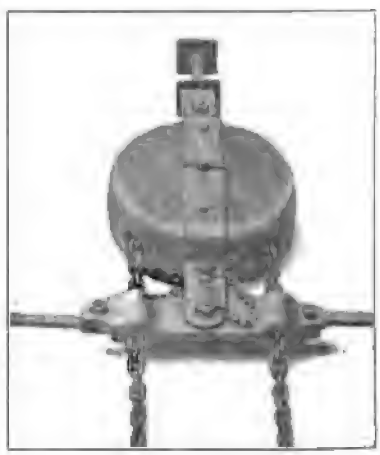

FIG. 1.—HARDMAN SPUNNEY-WHEEL: BRAKE FREE.

Mr. WALTER HARDMAN (Walkden) explained the mechanism of the appliance, which he said had been at work for some time and had proved quite satisfactory. The arrangement for putting on the brake was very simple and positive in action. It ap-

plied itself automatically in either direction, excepting when the operator held the lever in the running position. Provision was made, however, whereby the insertion of a pin in the quadrant held the brake in the free position. The brake could be operated from either side, the man standing by preference on the side from which the waggons were running away. In case it became necessary for him to pull the chain in order to assist them, the pull was in the direction away from the wheel, so that there was little chance of his hand being caught. There was nothing complicated about the construction, nor did the parts become unreliable through wear. The method of attachment to the post was by a joint-bolt, or a lashing-chain round the post, which could be fixed in a few moments.

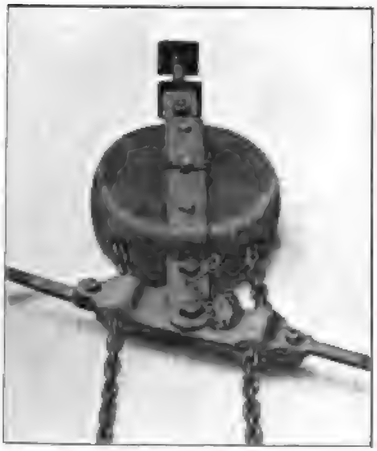

FIG. 2.—HARDMAN SPUNNEY-WHEEL: BRAKE IN ACTION.

FENCE-GATES AND PROTECTORS FOR CAGES IN SHAFTS.

Mr. JOHN GERRARD (H.M. Inspector of Mines, Worsley) further invited attention to a model and photographs of several fence-gates for cages in shafts. The model exhibited was the production of Mr. Henry Houghton, of Skelmersdale. Such fence-gates were in use at Lord Lathom's collieries at Skelmersdale, at the Hulton collieries, and at the Denaby Main collieries. The cage-gates at the latter collieries were automatic, and were the invention of Mr. W. H. Chambers, the arrangement being applicable for the protection of both tubs and men. On arriving at the top or bottom, by certain levers being worked, the gate was raised. Mr. Gerrard explained the points of difference in the several arrangements at these collieries. He favoured the use of gates for cages. There had been a number of accidents in shafts in connection with men riding, and, in his opinion, the use of fence-

gates would prevent such accidents. He was glad to note an increasing desire on the part of mine-owners and managers to adopt some simple precaution for the prevention of accidents in the shaft, and thought that it would be interesting to members to have these things brought under their notice.

FIG. 1.—HOUGHTON PROTECTIVE CAGE-GATE AS USED AT LORD LATHOM'S COLLIERIES, SKELMERSDALE: SHOWING METHOD OF OPENING GATE.

The Houghton fence-gate (figs. 1 to 4) would not open by pressure from the inside. To open the gate, it was pushed inwards a little, the lower part raised about its hinges, so as to clear the recess, and then swung outwards. The gate generally fell into its locked position, by gravity, when released. In lieu of hinging the lower part, the same could be made telescopic, and in order to remove the gate from its holding-recess it was simply raised, the

lower part sliding on the upper. The gate could, of course, be readily opened from the inside, if desired. When out of use, the gate was slung under the roof of the cage.

FIG. 2.—HOUGHTON PROTECTIVE CAGE-GATE: SHOWING GATE CLOSED.

The arrangement of the Chambers automatic cage-fence was such that when the cage left either the pit-bottom or top, the fence-bars automatically descended, closing the cage-end, and effectually preventing egress, through accident or otherwise, of either man or tubs, in the event of the ordinary stops failing. The fence-bars were raised automatically when at the landings.

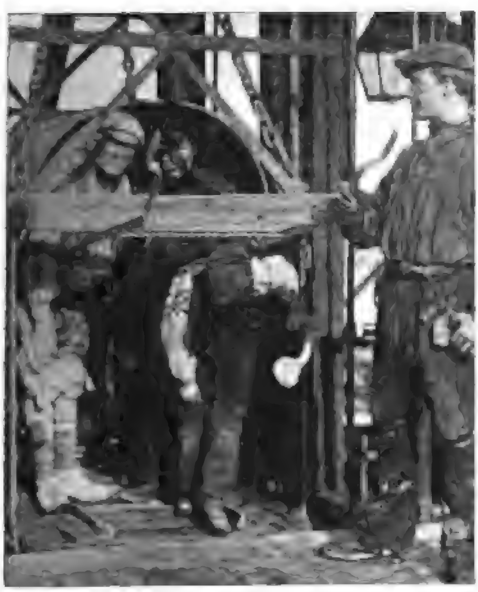

FIG. 3.—HOUGHTON PROTECTIVE CAGE-GATE: SHOWING GATE OPEN AND MEN ALIGHTING FROM CAGE.

The open-end of the cage constituted a great danger; a moment's sickness, causing a sensation of giddiness, might result in the miner so afflicted falling out and meeting a violent death. The cage-gates referred to were intended to remove this element of danger. The use of such gates would also prevent any sudden

attempt being made to enter the cage after the signal for lowering or raising had been given

Mr. VINCENT BRAMALL (Pendlebury) moved a vote of thanks to Mr. Gerrard.

Mr. JOSEPH DICKINSON (Pendleton), in seconding the resolution, said that fence-gates should be automatic in their action, light in weight, and such as would prevent a man or a tub from falling into the shaft. Much had been done within his recollection to avoid shaft accidents, and it was pleasing to find improvement still being aimed at. Formerly, he had been one of upwards of a dozen persons to descend the shaft with three loops in the coupling-chain, two men each with one leg in each loop, a boy on each of their knees, and some sticking on at couplings. Nowadays the usual thing was to step into a cage, where there was a bar or something to lay hold of.

FIG. 4.—HOUGHTON PROTECTIVE CAGE-GATE: GATE OUT OF ACTION AND SLUNG UNDER ROOF OF CAGE.

There were few, if any, hoists or man-engines in our colliery shafts, but there were some at metalliferous mines. When the latter mines came within the Mines Regulations Acts, some of these hoists were without sufficient provision for safety. Accordingly, provision was agreed to for the Special Rules in the Manchester and Ireland district, providing for the installation of fend-off boards, or a hinged board to lift, and at the stepping-off places a handle or something to lay hold of where there was any hole to fall into.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
DECEMBER 10TH, 1907.

MR. JOHN ASHWORTH, PRESIDENT, IN THE CHAIR.

The following members were elected, having been previously nominated:—

MEMBER—

Mr. CHARLES DAVIS TAITE, Electrical Engineer, 196, Deansgate, Manchester.

STUDENT—

Mr. RALPH HAMPSON, Mining Student, Shotton Cottage, Shotton, Queen's Ferry, S.O., Flintshire.

THE LATE MR. M. WALTON BROWN.

The PRESIDENT (Mr. John Ashworth) reminded the members that since their last meeting the mining world had suffered a great loss by the death of Mr. Martin Walton Brown, Secretary of The Institution of Mining Engineers.

Mr. JOSEPH DICKINSON (Pendleton) thereupon moved the following resolution:—

"The President, Council, and Members of the Manchester Geological and Mining Society, in general meeting assembled, receive with profound regret the intimation of the death of Mr. Martin Walton Brown, the Secretary of The Institution of Mining Engineers, and desire to express their deep sympathy with Mrs. Brown and her family in their sudden bereavement. The members also desire to express their high appreciation of the long and valuable services rendered to The Institution of Mining Engineers and to the mining profession generally by the late Mr. M. Walton Brown, whose departure from amongst them is a great loss to the mining world."

Mr. JOHN GERRARD (H. M. Inspector of Mines, Worsley), in seconding the resolution, said that he had known Mr. M. Walton Brown for over thirty years. They all knew how high Mr. Brown

had carried the banner of mining, not only throughout the mining districts of this country, but throughout the mining districts of the world. The least that they could do, therefore, was to pass this resolution of sympathy with those who had been overwhelmed with sorrow in so sudden and so sad a manner. The valuable work which Mr. Brown had done would be remembered and appreciated for many years.

The resolution was passed in silence, all the members rising from their seats.

SPECIMENS OF COAL FROM CALDER COLLIERY.

Mr. John Gerrard (H.M. Inspector of Mines, Worsley) exhibited some interesting specimens of coal taken from the Calder colliery, representing the Arley Mine and the Lower Mountain Mine. The distance between the two seams was 6 inches less than 900 feet. This being the first time that the distance between these seams had been actually measured, it seemed to him a notable occurrence, and one worthy of being brought before the Society.

The specimens of marine shells produced came from the two marine beds associated with these seams.

GAUZES IN BONNETTED SAFETY-LAMPS.

Mr. John Gerrard (H.M. Inspector of Mines, Worsley) exhibited Mr. Walshaw's appliance for securing the presence of gauzes in bonnetted safety-lamps. At the last meeting of the Society, he had shown a similar invention,* and on that occasion there was some controversy as to the complete utility of the device. The idea of this particular invention was to have a tab attached to each gauze, which showed in the glass so that if the two tabs were not seen there was evidence that the gauzes were not in the lamp.

Mr. W. H. Coleman read the following paper on "Bye-products from Coke-ovens":—

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 321.

BYE-PRODUCTS FROM COKE-OVENS.

By W. H. COLEMAN.

The exhaustion of our coal supply is proceeding at such a rapid rate that it is necessary to take care that the energy contained in every ton of coal should be utilized to the fullest extent possible, not perhaps that the pinch may be felt in our own time, but because it is our duty to leave as much of our heritage of power as possible to our descendants. The increase in the population of the world is a warning that the question of food supply will be an urgent one in the near future. We have for years been existing upon the stored up wealth of the virgin soils of America and other sparsely-peopled districts, but this cannot go on for ever, and the continued abstraction of plant food from the soil must be compensated for in some way or other. The two most important ingredients permanently removed from the soil by the crops are phosphorus and nitrogen. With the former the writer does not propose to deal in these notes, but he intends to confine his remarks to the latter as being closely concerned with one of the chief bye-products of coke manufacture, namely, sulphate of ammonia, which is at present the only practicable means of returning to the soil the nitrogen which has been abstracted by the crops. No doubt the deposits of nitrate of soda in South America have to a large extent supplied up to the present time the demand, but they are being rapidly exhausted at an ever increasing rate, and until the production of nitrogen-compounds from the air can be accomplished at a reasonable cost, the gap left can only be filled by sulphate of ammonia.

The introduction of motor vehicles has opened an avenue of usefulness for the bye-product recovery-oven, and provides an outlet for the other two of the three chief bye-products, namely, for the benzol as a motor fuel, and for the tar as a means of combating the dust nuisance, which is made more visible, if it is not entirely caused, by motor traffic.

It may now be desirable to give a few figures showing to what extent the production of coke in recovery-ovens has progressed in this and in other countries. Taking Great Britain first, it was stated in the Report of the Royal Commission on Coal-supplies of 1905* that in the year 1902 only about 10 per cent. of our total output of coke was made in recovery-ovens, and it was then suggested that returns should be obtained showing the annual increase in the use of this kind of coke-oven; and, although owing to the want of powers to compel returns no exact figures can be obtained yet for the last two years, the following figures, published by the Home Office, are extremely interesting:—†

TABLE I.—TONS OF COAL COKED DURING 1905 AND 1906, AND VALUE OF COKE PRODUCED.

Year.	Coal Used.	Coke Made.	Value.
	Tons.	Tons.	£
1905	33,452,943	18,037,985	10,625,799
1906	35,402,677	19,296,526	12,549,116

TABLE II.—NUMBER AND DESCRIPTION OF COKE-OVENS.‡

Year.	Beehive.	Simon Carvés.	Semet-Solvay.	Coppée.	Bauer.	Koppers.	Otto-Hilgenstock.	Simplex.	Other Kinds.	Total.
1905	25,514	726	470	2,233*	52	72	503	—	1,490	31,060
1906	23,454	808	670	2,308	52	108	768	78	1,482	29,728

* Some Otto-Hilgenstock ovens are included in these figures.

TABLE III.—NUMBER OF BEEHIVE AND RETORT COKE-OVENS IN 1905 AND 1906.

Year.	Beehive.	Retort-ovens.	Total.	Percentage of Retort-ovens.
1905	25,514	5,546	31,060	17·85
1906	23,454	6,274	29,728	21·11

From the above tables it will be noted that the number of beehive-ovens has decreased from 25,514 in 1905 to 23,454 in 1906, and the recovery and retort-ovens have increased from

* *Final Report of the Royal Commission on Coal-supplies*, 1905 [Cd. 2353], part i., general report, page 9.

† *Mines and Quarries: General Report and Statistics*, 1905 [Cd. 2974], page 195, and 1906 [Cd. 3774], page 180.

‡ *Ibid.*, 1905, page 196; and 1906, page 181.

5,546 in 1905 to 6,275 in 1906, or a decrease in the first case of about 8 per cent., and an increase in the second case of about 13 per cent.

Although no figures are given showing the proportion of coke made in recovery-ovens, for the quantities given in Table I. refer to all coke manufactured, including that made at gas-works, it is possible by a somewhat roundabout calculation to arrive at an approximate estimate. Table IV. gives the production of sulphate of ammonia in each year, and the writer considers the figures interesting for two reasons, namely, (1) they show the increase in the recovery of ammonia as sulphate from coke-works for the past nine years, and (2) from these figures the approximate calculation to which the writer has referred has been made.

TABLE IV.—PRODUCTION OF SULPHATE OF AMMONIA FROM 1898 TO 1906.*

Year.	Gas-works.	Iron-works.	Shale-works.	Coke-ovens.	Producer and Carbonizing Works.	Total.
1898	129,590	17,935	37,264	5,403	6,165	196,357
1899	133,768	17,963	38,780	7,849	7,360	205,720
1900	142,419	16,959	37,267	10,393	6,688	213,726
1901	142,703	16,353	40,011	12,255	5,891	217,213
1902	150,035	18,801	36,931	15,352	8,177	229,316
1903	149,489	19,119	37,353	17,438	10,265	233,664
1904	150,208	19,568	42,486	20,848	12,880	245,990
1905	155,957	20,376	46,344	30,732	15,705	269,114
1906	157,160	21,284	48,534	43,677	18,736	289,391

From the foregoing table it will be noticed that the production of sulphate of ammonia from coke-ovens has risen from 5,403 tons in 1898 (the first year for which separate figures are given for coke-ovens) to 43,677 in 1906, or an increase of over 800 per cent., the increase in the last three years being especially noticeable.

The yield of sulphate of ammonia may be taken in round numbers as 25 pounds per ton of coal carbonized, either from gas-works or from coke-ovens (possibly 28 or 30 pounds in many cases may be obtained, but the writer prefers to take the lower figure as being probably the actual yield).

If a calculation be made, on the above assumption, from the quantity of coal carbonized in gas-works, and the figure subtracted from that given in Table I., it will show the quantity of

* *Annual Reports of the Chief Inspector under the Alkali Act.*

coal carbonized in coke-ovens; and, if a further calculation on the same assumption be made, taking the quantity of coal carbonized in coke-ovens where sulphate of ammonia was made and deducting, the remainder will show the quantity of coal carbonized in beehive and other non-recovery ovens. The following table shows the results for the years 1905 and 1906:—

TABLE V.—COAL COKED DURING 1905 AND 1906.

Year.	Gas-works.	Coke-works, all kinds.	Coke-works, Recovery-ovens.	Coke-works, Non-recovery Ovens.	Total Coke Coked.
	Tons.	Tons.	Tons.	Tons.	Tons.
1905	13,973,747	19,479,196	2,753,587	16,725,609	33,452,943
1906	13,991,936	21,410,741	3,914,899	17,495,842	35,402,677

TABLE VI.—PERCENTAGE OF COAL COKED IN RECOVERY AND IN NON-RECOVERY OVENS.

Year.	Non-recovery Ovens.	Recovery Ovens.
	Per cent.	Per cent.
1905	83·9	16·1
1906	81·8	18·2

The above estimated figures agree fairly well with those given for the year 1905 by Mr. Ernest Bury in his most instructive paper read before the Institution of Gas Engineers at Dublin in June, 1907,* wherein, calculating from quite different assumptions, he gives the following figures:—

TABLE VII.—COAL COKED DURING 1905.

Year.	Gas-works.	Non-recovery Coke-ovens	Recovery-ovens.	Total.
	Tons.	Tons.	Tons.	Tons.
1905	14,180,000	16,000,000	3,317,000	33,497,000

The following figures are taken from the Mines and Quarries Report†:—

TABLE VIII.—NUMBER AND PERCENTAGE OF WORKS RECOVERING BYE-PRODUCTS FROM COKE DURING 1905 AND 1906.

Year.	Number of Works from which Returns were Received.	Number of Works at which Bye-products were Recovered.	Percentage of Works at which Bye-products were Recovered.
1905	271	46	17·1
1906	257	51	19·8

* *The Journal of Gas Lighting*, 1907, vol. xcviii., page 982.

† *Mines and Quarries: General Report and Statistics*, 1905 [Cd. 2974], page 196; and 1906 [Cd. 3774], page 181.

Turning to other countries, the world's production of coke is given in metric tons in the Bulletin No. 2,706 of the Comité des Forges, published September 30th, 1906, as follows:—

TABLE IX.—WORLD'S PRODUCTION OF COKE.

Country.	1904. Metric Tons.	1905. Metric Tons.
United States of America	21,465,355	29,240,080
United Kingdom	—	18,326,593
Germany	12,331,163	16,491,427
France (in part only)	1,673,519	1,907,913
Belgium	2,211,820	2,238,920
Russia	2,402,878	2,374,335
Austria	1,282,473	1,400,283
Italy	607,297	627,984
Spain	605,318	641,689
Canada	493,107	622,154
Australia	173,750	165,576
Hungary	5,103	69,303
Mexico (estimated)	60,000	60,000
Other Countries (estimated)	2,000,000	2,200,000
Totals	45,311,783	76,366,257

N.B.—1 metric ton = 0·9839 English ton.

In reference to the above figures, it should be mentioned that no statement was made to show whether or not they included the coke produced at gas-works. The return for the United Kingdom, as shown by comparison with the figures of the Board of Trade return, included the gas-works production, but that for Belgium did not, as the figure given was the same as that stated in the Belgium Government report as the production of 39 coke-works. The writer has unfortunately been unable to check the other figures.

The United States.—In the year 1901, 5 per cent., and in 1905, 10·74 per cent., of the total production of coke was made in recovery-ovens. In the latter year, there were in the United States of America 3,159 recovery-ovens out of a total of 87,564 ovens of all kinds, or 3·6 per cent.

Germany.—In the year 1901, 53 per cent. of the total production of coke was made in recovery-ovens, and the writer was informed by a competent authority when in Germany last year that 90 per cent. of the coke was at that time being made in recovery-ovens.

France.—The *Colliery Guardian** gave the production in France during the year 1905 as follows:—Gas-works. 2,300,000 tons; coke-works, 2,603,522; total, 4,903,522. There were 2,512 beehive and 1,604 recovery-ovens, the latter being 38·97 per cent. of the total number. The coke produced in recovery-ovens was 1,543,000 tons, being 31·46 per cent. of the total coke produced.

Belgium.—In the year 1904, 1,700,000 tons of coke were produced in 911 bye-product ovens, and in 1905, 2,238,920 tons of coke were produced in 39 coke-works.

Spain.—In the year 1901, about 200,000 tons of coke were produced in coke-ovens of the Semet-Solvay and Simon Carvés types at Altos Hornos and Sestao.

The writer regrets that he has been unable to obtain more recent or more extensive figures, but he believes that enough has been given to show that Great Britain is a long way behind the other nations of the world, except perhaps the United States of America, in the adoption of bye-product ovens. That steps are being taken to remedy this condition of affairs may be seen from Table X., which cannot, however, be considered complete.

TABLE X.—RECOVERY-OVENS EITHER JUST COMPLETED OR AT PRESENT (1907) UNDER CONSTRUCTION IN THE UNITED KINGDOM.

Description.	Number.
Simon Carvés	500
Semet-Solvay	449
Koppers	160
Otto-Hilgenstock	200
Simplex	88
Coppée	353
Total	1,750

The three main products obtained in the process of coking or carbonizing coal, when coal is destructively distilled, are as follows:—Solid, coke; gaseous, heating or lighting gas and ammonia; liquid, tar and benzol or naphtha.

The first of the above, namely, coke, the writer must leave

* 1906, vol. xcii., page 663.

to those who have much more practical experience of the matter than himself. However, he would like to point out that the old objection to bye-product coke is slowly but surely giving way. Recovery-coke is, if properly slacked, quite equal to bee-hive-coke in respect to its appearance, or sulphur content, and its ability to stand the burden of the charge in the blast-furnace. Further, the introduction of mechanically-charged blast-furnaces requires a coke of smaller size than formerly, which will lead in the future to a more extensive use of the bye-product variety.

TABLE XI.—ANALYSES OF VARIOUS KINDS OF COKE (DRY).

Constituent.	Bye-product Coke.	Beehive-Coke.	Gas-works Coke.
	Per Cent.	Per Cent.	Per Cent.
Ash	6·00	8·0	9·90
Volatile matter	1·86	not estimated	1·65
Fixed carbon (by difference) ...	92·14	91·90	88·45
Totals	100·00	100·00	100·00

The second class of products, namely, the gaseous, consists of heating gas and ammonia. At the present day, nearly all coke-works utilize at least a portion of the gas for other purposes than heating the ovens. It has a high calorific value, as will be seen from the following table, taken from that given by Mr. F. L. Slocum*:—

TABLE XII.—CALORIFIC VALUES OF VARIOUS GASES.

Name of Gas.	British Thermal Units per Cubic Foot.
Oil-gas	1,350
Natural gas	980
Coal-gas	600 to 628
Coke-oven gas	367 to 686
Water-gas	500
Mond gas	156
Siemens gas	137

In this connection it is interesting to note a suggestion recently made that a producer-gas plant should be combined with a coke-oven plant, especially where both poor and rich coals occur in the same locality. The producer being fed with the poor coal (coal with a small percentage of volatile matter),

* "A Comparison of Fuel-gas Processes," by Mr. F. L. Slocum, *The Journal of the Society of Chemical Industry*, 1897, vol. xvi., page 420.

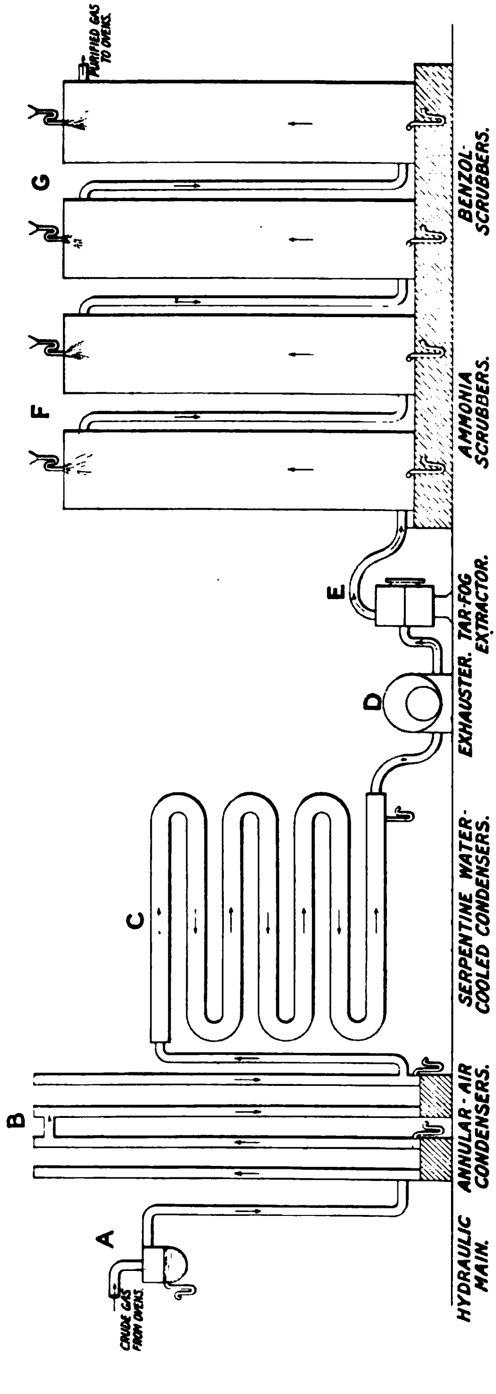

FIG. 1.—RECOVERY OF AMMONIA, TAR, AND BENZOL FROM COKE-OVEN GAS.

even the waste coke, breeze, etc., might be used; and the gas of low calorific power used for heating the coke-ovens; the high-value gas from the ovens being used to produce power by means of gas engines. Coke-oven gas is eminently suited for such a purpose, being of high calorific value and comparatively clean, whereas producer-gas is very difficult to free from dust, and especially from tar, much more so than coke-oven gas. Of course, the great difficulty in the way is the question of storage of power, but consideration of that point is beyond the scope of this paper.

Coke-oven gas is largely used in the United States of America for lighting purposes, and the extension of its use in this direction might with advantage be undertaken in this country. The gas,

especially that evolved during the earlier stages of carbonization, is of high illuminating value, and it has been proposed to collect the first portions separately for use as an illuminant. The remaining products—ammonia, tar, and benzol—now require consideration. It would perhaps be best to first consider the question of their recovery from a general point of view, and to this end the writer invites attention to the rough diagram (fig. 1) which he has made to illustrate the principles underlying the process. The gas as it comes from the ovens has a very high temperature, and the first step towards the recovery of the bye-products is to reduce the temperature to the normal. From the ovens the gas enters a common main extending the whole length of the ovens, which is known as the hydraulic main, A, where the temperature falls to about 212° Fahr. (100° Cent.), and a considerable portion of the tar and water-vapour is condensed. The latter absorbs some of the ammonia. The gas passing from the hydraulic main still contains tar in the state of fog or mist, in addition to ammonia gas and benzol vapour. It is, therefore, still further cooled by passing through either annular or serpentine air-cooled pipes, B, and then through a series of water-cooled pipes, C. By this means, its temperature is brought down nearly to that of the atmosphere, and a further quantity of tar and ammoniacal water deposited, which is allowed to drain away by S-shaped siphon pipes, and conveyed to store tanks or wells. The gas next passes to the exhausters, D, which serve to draw the gas from the ovens through the coolers and to force it through the rest of the apparatus described later. Two different types of exhausting apparatus are used, the rotary mechanical exhauster and the steam injector. The latter has the advantage of producing a more constant suction and of being free from mechanical complications, but has the drawback of heating the gas so that it has to be passed through another cooler. The gas from the exhausters, D, still contains tar-fog, ammonia, and benzol vapour, and is generally next passed through some form of tar-fog extractor, E. The two most important types of this apparatus are the Pelouze and Audouin, and the Mallet extractors, being based on the same principle, namely, condensation by shock. The tar particles exist in the gas in the state of little vesicles or bubbles of tar filled with gas, which are extremely minute and very difficult

to condense. Within the apparatus a number of screens of perforated metal sheets, placed only a short distance apart, are so arranged that the holes in one plate are opposite the blank surface of the next. The vesicles pass through the perforations with considerable velocity, striking against the surface of the plate in front. The shock of the impact breaks up the vesicles, and causes the tarry matter to adhere to the surface of the plate down which it trickles to the store tank below. Both types have a tendency to get blocked with tar; and to contend with that difficulty the Pelouze apparatus is so constructed and connected to the system of gas-mains that it can be cut out of the path of the gas from time to time and the top removed, so that the dirty plates can be taken out and replaced by clean ones and the apparatus then put in action again. In the Mallet apparatus, the perforated plates, or rather drums, are slowly and continuously revolved, so that the lower portions pass into warm tar contained in the bottom of the casing. The perforations are thus continuously washed by the warm tar. The necessity for the use of the tar-fog extractor will be explained later in the process for the recovery of the benzol vapour. The gas is next passed through the ammonia scrubbers, or washers, F, where the ammonia is absorbed. These consist either of vertical towers filled with chequer-work of bricks, rings, boards, or even with coke; and the gas passes up the towers and is met by a stream of water flowing down. The second type of ammonia-absorber is the rotary mechanical washer of the Holmes or the Standard pattern. This apparatus consists of a horizontal cylinder divided by vertical partitions into a number of compartments, a shaft passing horizontally through the cylinder, a number of brushes or bundles of laths being fixed upon the shaft, one in each compartment. A current of water is caused to flow through the cylinder from one end to the other, from chamber to chamber, each being about half filled with the liquid, and the gas to be washed being caused to flow through the upper part of the chambers in the opposite direction. As the shaft revolves, each portion of each brush dips into the liquid and is afterwards exposed to the current of gas.

The most important points to be borne in mind in carrying out this part of the process are to arrange that the temperature of both gas and water are as low as possible, and that the currents

of gas and washing-liquid flow in opposite directions. If tower scrubbers are employed, it is necessary to ensure a good distribution of the washing liquid; and for this purpose the Zschockesche patent distributer is one of the best types, being easy to regulate, as the glass-sight allows the attendant to see if it is working properly.

The next process is the recovery of the benzol, or rather the mixture of hydrocarbons in the gas in which benzol predominates, which is effected by passing the gas through an exactly similar apparatus, G, to that used for ammonia recovery. The benzol is absorbed by a hydrocarbon oil, and for this purpose creosote or anthracene oil is used, which absorbs the benzol vapours, and is afterwards sent to a still where the benzol is separated by fractional distillation. The oil, after cooling, is used over and over again, until it becomes too strongly charged with tar and naphthaline (a crystalline hydrocarbon occurring among the products of distillation of coal, and particularly difficult to separate from the gas) for the purpose, when it is either mixed with the tar or sold separately. In order that this oil may be used as many times as possible, the tar-fog previously mentioned must be extracted completely from the gas. The scrubbed gas is then returned to the ovens and burnt in the flues to effect the coking of the coal, but in most cases a considerable surplus is available for other purposes: this varying, of course, with the quality of the coal, the type of ovens employed, and the care and attention given to the process. It could be used directly in gas-engines for the production of power, or employed for lighting in the works or neighbourhood. For the latter purpose, the gas ought to be further purified by passing it through hydrated oxide of iron, in order to remove the sulphuretted hydrogen which it contains.

Having described how the products are obtained, it remains to say something about their disposal, and these will be considered in the same order as before, namely, tar, ammonia (now in the form of a weak solution), and benzol (in the form of an impure mixture of hydrocarbons known as crude benzol or crude naphtha).

The tar is always sold as such to the tar distiller, who, by distillation and subsequent washing and rectification, pro-

duces the finished first products. These comprise benzol, toluol, solvent naphtha, creosote oil, naphthaline, carbolic acid, anthracene, and pitch, which are used in the colour, rubber, and explosive industries, as well as for preserving timber, for paving, asphalting, briquetting coal, preparing disinfectants, making lamp-black, roofing-felt and many other purposes. In addition, the tar itself is now largely used to overcome the dust nuisance, made so obvious by the rapid increase in the use of motor-cars. For this purpose the crude tar is not so suitable as the refined product obtained by distilling off the lighter hydrocarbons, which render the tar too fluid, and consequently too easily softened by the heat of the sun, and which also tend to separate after its application to the roads, especially in wet weather, as a most objectionable oily film or scum. The tar could be applied in two ways, either as a coating spread over a road not in need of repairs, when it acts both as a preventive of dust, and as a preservative of the road material. Experiments carried out in France over several years* proved that not only were the tarred roads free from dust, but also that they lasted longer, and that the cost of cleaning was much reduced, so that although the cost of application might be considerable it was counterbalanced by the saving effected. To gain some idea of the quantity of tar that might find application for this purpose, the writer will quote figures given by Mr. Maybury in a paper read by him at Dublin in 1907.† About 7 tons of tar were required for each mile of road of the average width, the mileage of roads in England and Wales being given as follows:—Main roads, 23,826 miles; other public roads, 95,211 miles; total, 119,037 miles. If these were all tarred, there would be required:—For main roads, 166,782 tons of tar; for other public roads, 666,477 tons of tar; being a total of 833,259 tons of tar.

Another method in which tar is used in road construction is that of paving the road with a mixture of broken stone or slag with tar or pitch, known as "tar macadam." This is, no doubt, the more serviceable way, as the painting of the surface is at best only a palliative, while tar macadam, in addition to the prevention of dust, gives a good hard road which is reported to last extremely well.

* *Annales des Ponts et Chaussées*, eighth series, 1905, vol. xx., page 260.

† *The Journal of Gas Lighting*, 1907, vol. xcviii., page 972.

The tar produced in coke-works varies in composition, but approximates to that obtained at gas-works, and contains the same compounds, although in somewhat different proportions. It differs altogether from blast-furnace and producer-tars, which are much less valuable.

Turning to the ammonia, which, as stated above, is recovered as a weak solution in water, the chief compounds present are shown in Table XIII. and compared with the liquor obtained at gas-works.

TABLE XIII.—COMPOSITION OF AMMONIACAL LIQUOR.

Name of Constituent.	Ammoniacal Liquor: From Gas-works.	Ammoniacal Liquor: From Coke-works.
Specific gravity at 60° Fahr.	1·028	1·011
	Grammes per 100 Cubic-centimetres.	Grammes per 100 Cubic-centimetres.
Free ammonia (NH)	1·928	0·841
Fixed do.	0·545	0·102
Total do.	2·473	0·943
Sulphuretted hydrogen	0·510	0·233
Carbonic acid	2·274	0·899

The ammonia compounds are divided into two classes, free and fixed, the former comprising those compounds of ammonia which are dissociated by simple heating, and the latter those which require the addition of lime or of some other alkali to decompose them. The ammonia-water obtained from coke-ovens is generally weaker than that from gas-works, probably because the washed coal contains more water, although it should be possible to improve the strength somewhat by careful attention to the scrubbers. The ammonia water is distilled by steam and the gas passed into sulphuric acid, with which the ammonia combines, forming sulphate of ammonia. It should contain from 24 to 24·5 per cent. of ammonia, and be reasonably dry and free from excess of acid. Its colour should be as white as possible, in order to obtain the best price, and care is required to attain this. If acid containing arsenic is used, the resulting sulphate will be yellow, and may be refused. It may be worth while to give one or two hints as to the cause of discoloration and the means of preventing it. The dirty grey colour often observed is due, not to dark-coloured acid to which it is generally

attributed, but to one of two causes which could with care be easily avoided. The first is the priming of the liquor in the still, and the second is the occurrence of local alkalinity in the saturator or vessel in which the ammonia is absorbed by the sulphuric acid, which may be due either to a deficiency of steam, which often results in solid sulphate building up over the perforations in the gas pipe, or to carelessness of the workman in not feeding the acid with sufficient regularity. Either of these causes may also result in the formation of blue salt, which is very troublesome, and renders the product unsaleable. The ammonia-water contains hydrocyanic or prussic acid (which distils over with the ammonia), carbonic acid, and sulphuretted hydrogen, and which, in the presence of iron (always found in commercial acid), and free ammonia, forms ferrocyanide or yellow prussiate of ammonia. This compound, as soon as the saturator becomes acid again, is decomposed, and forms white ferrocyanide of iron, which rapidly oxidizes into prussian blue and discolours the sulphate. The remedy is then to use a sufficient excess of steam to keep the contents of the saturator continually boiling, and to see that the contents are never allowed to become alkaline for want of acid. Care as to these details would save much annoyance. The carbonic acid and sulphuretted hydrogen, along with some hydrocyanic acid, escape from the top of the saturator, and as these gases are not only objectionable but also very poisonous, they should be treated, and are not allowed to be turned out into the air. They are, therefore, after cooling, either passed through a purifier or box containing hydrated oxide of iron, when the sulphuretted hydrogen is decomposed into water and sulphur and the hydrocyanic acid is arrested as prussian blue, or the gases mixed with a suitable proportion of air and passed through a Claus kiln or chamber containing oxide of iron, which acts as a catalytic agent, and the sulphuretted hydrogen is partly burnt to sulphurous acid, which reacts on the rest of the sulphuretted hydrogen, forming water and sulphur. This, by the way, is an interesting reaction, as the sulphur found near the vents of volcanoes is probably formed in a similar way. The waste liquor from the stills, containing lime-salts and phenols, cannot be turned into rivers or water-courses; but the various methods that have been proposed for its treatment cannot be described in this paper. The writer would, however, refer anyone

interested in the question of the composition of this effluent to the paper by Messrs. Franklin and Silvester,* read before the Society of Chemical Industry, and to the paper by Dr. F. W. Skirrow read before the Manchester section of the same Society.†

The last product to be dealt with is the benzol, which, as was mentioned before, is recovered as a solution of benzol in creosote-oil. The oil containing the benzol is run through a still somewhat similar to that used for the ammonia, and the low-boiling benzol continuously distilled off, while the creosote oil may, after cooling, be used over again. The product obtained, generally that known as 65 per cent. benzol, is a material giving a distillate of 65 per cent. at a temperature of 248° Fahr. (120° Cent.). It is sold to the refiners, who work it up into benzol, toluol and solvent naphtha.

The processes of recovery having been briefly described, it may be worth while to turn attention to the yields from the coal and the possible outlet for the products. The yield of bye-products, of course, depends chiefly upon the amount of volatile matter in the coal carbonized, and also upon the method of coking; but it may be taken as a conservative estimate that the yields are somewhat as given in Table XIV.

TABLE XIV.—YIELD OF PRODUCTS FROM CARBONIZING-COAL IN BYE-PRODUCT COKE-OVENS.

Coke	68 to 72 per cent.
Tar	6 to 8 gallons per ton of coal.
Sulphate of ammonia	25 to 30 pounds per ton of coal.
Naphtha, 65 per cent. ...	2 to 3 gallons per ton of coal.

Upon reference to Table V. it will be seen that in the year 1906, approximately 4,000,000 tons of coal were coked in recovery-ovens, about 17,000,000 tons in non-recovery ovens, and about 14,000,000 tons at gas-works. The yield of bye-products at gas-works may be taken as follows:—Tar, 10 to 12 gallons; sulphate of ammonia, 25 to 30 pounds per ton of coal. Calculating from the above data, and using the lowest figure in each case, the estimated production for the year 1906 was as follows,

* "The Bacteriological Purification of Sewage containing a large proportion of Spent Gas Liquor," by Messrs. Percy F. Frankland and H. Silvester, *The Journal of the Society of Chemical Industry*, 1907, vol. xxvi., page 231.

† "The Determination of Phenols in Gas Liquors," etc., by Dr. F. W. Skirrow, *ibid.*, 1908, vol. xxvii., page 58.

assuming that all recovery coke-works recover tar, ammonia, and benzol, which is certainly not the case so far as benzol is concerned: —

TABLE XV.—YIELD OF BYE-PRODUCTS AT GAS-WORKS DURING 1906.

Source.	Tar.	Sulphate of Ammonia.	90 Per cent. Benzol.
	Tons	Tons.	Gallons.
Gas-works	700,000	156,000	1,500,000
Coke-works ...	120,000	44,000	4,000,000
Other sources ...	?	89,000	......
Totals	820,000	289,000	5,500,000

TABLE XVI.—POSSIBLE ADDITIONAL PRODUCTION IF ALL COKE WERE MADE IN RECOVERY-OVENS.

Tar	510,000 tons.
Sulphate of ammonia ...	190,000 tons.
90 per cent. benzol ...	17,000,000 gallons.

Dealing with these separately, it is found in the case of tar that the present production is about 820,000 tons and the possible increase about 510,000 tons, making together 1,330,000 tons as the possible production. The question as to whether this could be absorbed or not is a difficult one. The tarring of roads would, if universally adopted, present an outlet for about 800,000 tons, an amount greater than the possible extra production in 1906, but this is a question for the future. There are two other possible outlets for additional tar—an increase in the amount of small coal briquetted, and the carrying out of the suggestion that poor coals might be successfully coked after the addition of a certain proportion of tar or pitch.

With sulphate of ammonia the question is simpler: the increase of 100,000 tons in the last nine years has not caused the price of sulphate to fall, and there is no reason that the writer knows of to fear that a gradual increase would seriously interfere with the value of this material, as the demand for nitrogen for plant-food is almost unlimited. The Japanese have adopted wheat as a food in the place of rice, and are now large importers of sulphate of ammonia, and the Chinese and other nations may follow their lead.

With regard to benzol, there is a fairly bright outlook, the present production in 1906, estimated at 5,500,000 gallons, hav-

ing been all absorbed either for colour-works or for gas enrichment. During the last year it has come into extended use as a fuel for explosion-engines, and (so far as can be seen at present) this is the only use that can be largely extended. It is estimated that 30,000,000 gallons of petrol were used for motor-vehicles and other explosion-engines in this country last year and that the present rate of increase in its use is 5,000,000 gallons per year. Any large increase in the output of petrol must mean an increase in price, for it only forms a limited proportion of the crude petroleum from which it is made, and outlets have to be found for the residual burning and lubricating oils, paraffin, wax, and pitch, and this does not appear to be easy.

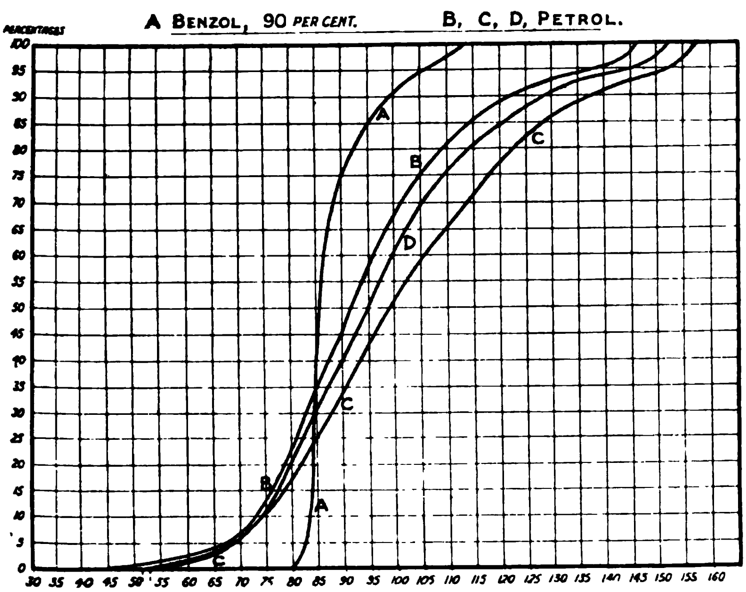

FIG. 2.—DISTILLATION-CURVES IN DEGREES CENTIGRADE.

The writer was informed by a very good authority that the supply of petrol is gradually approaching its limit, and that any further increase in the demand for motor fuel must be met from other sources; moreover, it is stated that the use of the heavier oils or paraffins in spray-carburetters is being seriously considered. In view of these considerations the demand for, and consequently the value of, benzol for this use is more likely to be increased than otherwise. Benzol is a very efficient fuel for motors, as, volume

for volume, about 20 per cent. greater efficiency can be obtained from its use. Its range of temperature on distillation is only about 86° Fahr. (30° Cent.), against 212° Fahr. (100° Cent.) for most samples of motor-spirit; and this is well illustrated by the curves (fig. 2), which show the temperature at which each 5 per cent. distils. This means that its efficiency is more constant, and that no trouble owing to the formation of stale spirit need be feared. It is a home-product, and the supply would not be interfered with in the event of political complications. If all the benzol possible were recovered, it does not equal the present demand for motor fuel, so that no fall in its value need be anticipated.

In conclusion, if the writer has interested the members sufficiently to induce them to consider the advisability of investigating for themselves the question of the adoption of recovery-ovens as a less wasteful process than the old one, he will have been amply repaid. His thanks are due to the proprietors of the various coke-ovens and to firms who have kindly supplied information given in the paper.

On the motion of the PRESIDENT (Mr. John Ashworth), seconded by Mr. SYDNEY A. SMITH, a cordial vote of thanks was accorded to Mr. Coleman for his interesting and most valuable paper.

The discussion of the paper was adjourned.

SECTION OF BORE-HOLE AT MESSRS. MARK FLETCHER AND SON'S WORKS AT MOSS LANE, WHITEFIELD, LANCASHIRE.

By JOSEPH DICKINSON, F.G.S.

As this part of the Lancashire coal-field is covered with deep drift, and as there are no colliery-workings in the immediate neighbourhood, the section is likely to prove of use to geologists and mining engineers.

The section was proved by Messrs. Chapman and Sons, Salford, while rope-boring for water, the actual strata being of secondary importance; but a few cores were taken as likely to be useful.

These cores were viewed by the writer and Mr. William Pickstone on September 18th, 1907, which resulted in the original section being thus detailed. The cores show the dip of the strata to be about 1 in 4½, and that the strata first met with appear to correspond to the red measures under the Permian Sandstone proved in the section at Heaton Park, as communicated by the writer to the Society, and printed in the *Transactions.**

The site of the Whitefield bore-hole is at the north side of Moss Lane, leading to Unsworth, about 1,200 feet from Four Lane-ends, and close to the western side of Messrs. Mark Fletcher and Son's works.

SECTION OF STRATA BORED THROUGH AT THE WORKS OF MESSRS. MARK FLETCHER AND SONS, LIMITED, MOSS LANE, WHITEFIELD.

Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
Loamy clay	15	0	15	0
Boulder-clay	109	0	124	0
Quicksand	18	6	142	6
Dark clay	5	6	148	0
Gravelly clay, with stones	5	0	153	0
Strong clay	9	0	162	0
Gravel	16	0	178	0
Mixed clay and gravel	5	0	183	0
Light-red clay, with bands of light-red shale	12	0	195	0
Beds of flag-rock ...	5	0	200	0
Red clay, with thin beds of shale	8	0	208	0
Red shale, with bands of sandstone ...	50	0	258	0
Red shale	68	0	326	0

* "Heaton Park Bore-hole, near Manchester, with Notes on the Surroundings," by Mr. Joseph Dickinson, *Trans. M. G. S.*, 1902, vol. xxviii., page 69.

Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
Fine sandstone ...	1	0	327	0
Soft red shale	55	0	382	0
Black shale	10	0	392	0
Mixed various-coloured shales	37	0	429	0
Various gritty shales ..	35	6	464	6
Close-grained hard sandstone	10	6	475	0
Gritty shale	2	0	477	0
Close sandstone-rock ...	5	0	482	0
Red gritty shale ...	18	0	500	0
Red shale, with thin beds of fine sandstone ...	24	0	524	0
Coarse sandstone ...	4	0	528	0
Shale, with thin bed of sandstone	3	0	531	0
Gritty shale	5	0	536	0
Coarse sandstone ...	14	0	550	0
Gritty shale	5	0	555	0
Sandstone-rock ...	35	0	590	0
Various coloured shales	14	0	604	0
Black soft shale ...	1	6	605	6
Grey shale	2	0	607	6
Grey shale, with bands of fine grey sandstone	3	0	610	6
Hard grey sandstone ...	2	0	612	6
Rag-rock	2	6	615	0
Grey shale	7	0	622	0
Hard band of grey rock	0	6	622	6
Fine flag-rock	4	0	626	6
Gritty shale	29	0	655	6
Very hard band of fine stone	0	6	656	0
Light-grey shale ...	15	0	671	0
Black shale, with thin seam of coal ...	5	6	676	6
Grey shale	38	6	715	0
Black shale	2	0	717	0
Mixed shale	1	6	718	6
Red gritty shale ...	3	6	722	0
Very hard gritty shale	2	0	724	0
Very hard fine sandstone	2	0	726	0
Hard gritty red shale ...	0	6	726	6
Red and black shales ...	1	0	727	6
Black shale	26	0	753	6
Hard grey shale ...	3	6	757	0
Grey shale	17	0	774	0
Black and grey shales ...	42	0	816	0
Shale, with thin hard band	2	0	818	0
Grey shale	4	0	822	0
Gritty grey shale ...	7	0	829	0
Grey shale	27	0	856	0
Mixed grey, black, and red shales, with bands of fine sandstone	3	0	859	0
Red shale, with beds of sandstone	4	6	863	6
Grey grit-rock	6	0	869	6
Mixed red and grey shales	8	6	878	0
Dark-red clay	1	0	879	0
Mixed red clay and shales	12	0	891	0
Grey shale	10	0	901	0
Grey rag-rock	2	0	903	0
Grey shale	9	6	912	6
Red clay and shale ...	2	0	914	6
Black shale and clay ...	1	0	915	6
Grey rag-rock	10	0	925	6
Grey rag-rock, with shale	2	0	927	6
Grey rag-rock	1	0	928	6
Black shale	0	6	929	0
Grey shale, with bands of rag-rock ...	5	0	934	0
Grey shale	4	0	938	0
Grey and black shale ...	2	6	940	6
Soft black shale ...	2	0	942	6
Mixed shales	2	0	944	6
Grey shale	12	0	956	6
Mixed grey and black shales	17	6	974	0
Rag-rock	1	0	975	0
Grey shale, with thin beds of rag-rock ...	2	0	977	0
Red shale	1	0	978	0
Total depth from surface ...			978	0

The details of the above proving by rope-boring are as follows :—

Well to 27 feet.

Borehole to 978 feet.

Tubing 20 inches in diameter, from 26½ feet to 93 feet below the surface.
,, 16 ,, ,, ,, ,, 26½ ,, ,, 226 ,, ,, ,,
,, 13¼ ,, ,, ,, ,, 40 ,, above bottom of the 16-inch tubing to 467 feet below the surface.
,, 11 ,, ,, ,, ,, the surface to 479½ feet.

The remainder of the hole was untubed.

A cordial vote of thanks was accorded to Mr. Joseph Dickinson and to Messrs. Mark Fletcher and Sons, Limited, for this addition to the information relating to the geology of the district.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS AND THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE INSTITUTE OF MINING ENGINEERS.

JOINT GENERAL MEETING,
HELD AT THE UNIVERSITY, BOURNBROOK, BIRMINGHAM,
DECEMBER 7TH, 1907.

MR. ALEXANDER SMITH (PRESIDENT OF THE SOUTH STAFFORDSHIRE AND WARWICKSHIRE INSTITUTE OF MINING ENGINEERS); AND, MR. G. J. BINNS (PRESIDENT OF THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS), JOINTLY IN THE CHAIR.

Mr. ALEXANDER SMITH cordially welcomed the members of The Midland Counties Institution to Birmingham.

DEATH OF MR. M. WALTON BROWN.

Mr. ALEXANDER SMITH said that he had the painful duty of moving a sincere vote of condolence to the wife and family of the late Mr. M. Walton Brown, the Secretary of The Institution of Mining Engineers. Having been on the Council of the Institution during the whole period that Mr. Brown had been in office, he (Mr. Smith) had had full opportunities of judging of his ability and capacity. As was natural, they had not always seen eye to eye with Mr. Brown in regard to details, but he (Mr. Smith) had always been convinced that Mr. Brown did his best for the Institution, and from thoroughly conscientious motives. His conduct of the business and affairs of the Institution had been recently thoroughly scrutinized by a committee composed of the secretaries of the various Federated Institutes, with the result that Mr. Brown's work had been highly commended. It was apparent to everyone that their excellent *Transactions* were a monument to his credit, and he might men-

tion that they were awarded a gold medal at the recent St. Louis Exhibition, a silver medal being also awarded to Mr. Brown for his work as editor. They all much regretted his loss, and it was certain that they would find it difficult to replace him.

The motion was seconded by Mr. G. J. Binns and supported by Mr. W. G. Phillips and Prof. R. A. S. Redmayne.

Mr. H. C. Peake (Walsall) said that he desired to be associated with the motion. He was greatly grieved to hear of the death of the late Secretary of the Institution, as during his (the speaker's) term of office as President of The Institution of Mining Engineers, and as a member of several of its committees, he had been closely connected with Mr. Brown, and had got to know him intimately. Mr. Brown's knowledge of mining was most extensive, and equal to that of any man of his (the speaker's) acquaintance. He had been a most efficient Secretary, and the Institution had lost a valuable servant.

Mr. F. C. Swallow (Hednesford) wrote that, as one who had been for several years intimately connected with the late Mr. M. Walton Brown, and who had been brought into perhaps closer touch with him than other members of the two Institutions represented at the meeting that day, some appreciative remarks from him might not be out of place.

In the year 1896, he (Mr. Swallow) was asked by Mr. Brown to assist in the compilation of the *Report of the Committee of The North of England Institute of Mining and Mechanical Engineers, and the Midland Institute of Mining, Civil and Mechanical Engineers upon Mechanical Ventilators*. This work, which was done mainly in the evenings and during the usual holiday-times, or at intervals when the business of the day was laid aside, involved a great deal of intricate detail-calculations, as the large number of experiments which had been made some ten years previously, upon the various types of mine-ventilators at different collieries in the principal coal-fields of this country, had to be summarized and a comparison of efficiencies made, by transforming the work done by each fan to a common basis. To anyone who had studied the Report, the nature of this intricate work would be at once apparent; and as to the writer was assigned the

task of compiling these figures and diagrams, under Mr. Brown's direction, he was brought into close touch with him for several years. He (Mr. Swallow) was then impressed by the amount of arduous work which Mr. Brown undertook during the periods when the majority of people were taking their well-deserved leisure. There was little doubt that the close attention to the work of editing the *Transactions* of The Institution of Mining Engineers, to which Mr. Brown devoted himself, had become too exacting to allow him to maintain robust health, for he worked almost incessantly in this connection, studying to make them of the greatest value to the mining community, and this made his range of knowledge most extensive. Personally, he was both genial and kind, and was always being appealed to for guidance or counsel on matters connected with the individual welfare of members of the mining profession all over the country.

By his untimely death the mining world had lost a most able and prominent figure, and one who had made himself almost indispensable in the position which he had held for so many years.

The motion was carried in silence, the members standing.

A vote of condolence was passed to the family of the late Walter H. Glennie, a member of The South Staffordshire and Warwickshire Institute of Mining Engineers.

The following gentlemen, having been duly nominated, were elected members of The Midland Counties Institution of Engineers:—

MEMBER—

Mr. WILFRED HENRY DAVIS, Electrical Engineer, All Saints' Works, Derby.

ASSOCIATE MEMBERS—

Mr. ALFRED GEORGE KIRKUP, Agent, Hazelwood Road, Duffield, Derby.
Mr. CHARLES FREDERICK ELLIOTT SMITH, Solicitor, Mansfield.

STUDENTS—

Mr. JOSHUA RUTTER PATTISON, Wollaton Collieries, Nottingham.
Mr. PERCY WOODVILLE PHILLIPS, Mining Pupil, Mansfield Colliery, Mansfield.

The following gentleman, having been duly nominated, was elected a student of The South Staffordshire and Warwickshire Institute of Mining Engineers:—

STUDENT—
Mr. N. FORREST, Essington, near Wolverhampton.

Prof. R. A. S. REDMAYNE conducted the members over the new buildings and laboratories of the University of Birmingham.

Mr. ALEXANDER SMITH read the following "Brief History of Coal-mining in Warwickshire":—

BRIEF HISTORY OF COAL-MINING IN WARWICKSHIRE.

By ALEXANDER SMITH.

When the writer had the pleasure of receiving on behalf of Mr. Newdegate the members of The Midland Counties Institution of Engineers at Arbury, he showed them a very interesting colliery account-book, which gave particulars of the developments made by Mr. Newdegate's ancestors in the seventeenth century. Mr. Bainbridge then requested that a paper should be written upon it at some future date, and from this interesting document, and also from an early slip-proof of the *Victoria History of the Counties of England*, kindly sent him by the editors, the writer has gleaned the following notes.

The earliest existing reference to coal-mining in Warwickshire is in connection with Chilvers Coton, where Alexander de Compton, in the year 1275, accounts for 36s. received for 1 perch of sea-coal sold, and in the following year he accounts for 103s. 4d. for 3 rods of sea-coal. Whenever profits arising from coal are mentioned throughout the medieval period, it is always found to have been sold by the rod or perch, showing it was the custom for the land-owner to sell the right to take coal from a certain area rather than to sell the coal itself. In 1338, pits were sunk near Nuneaton, as a quarrel is recorded between the parties; and a little later there are complaints and disputes as to taking coal, and not sharing the proceeds, namely, 20s. for two rods of coal. In 1350, the prioress of Nuneaton complained that sundry persons had with an armed force dug in the private land of the priory of Nuneaton, and carried away from thence sea-coal to the value of £40. There seems to have been a series of these offences, and another was the failure to close worked-out pits, so that the Coal-mines Regulation Act was evidently brewing at that early date; in fact, the fine was fixed, and amounted to 2s.

We may also infer that coal-getting was dry work in those days, as at present, for it is recorded that in the year 1380 the sum of 12 pence was given to several men called "coliems" for ale. During the reign of Richard II., the revenues from these mines averaged about 50s. per annum, but after the year 1400 there is very little reference to coal; so that it looks as if the easily-accessible portions had become exhausted. In 1544, coal-pits are again referred to, and in 1550 Sir Marmaduke Constable leased Blackwaterfeeld, in Nuneaton, to several persons, and reserved the right to dig for ironstone, colles, metal, and ore. In the year 1570, some experts were appointed to report upon what mines of coal there were in Bedworth, when they stated "there is one mine of coal called Stone-cole or Sea-cole in a place called Parkefield, and how far it extends they do not know, and the said mine of coals is worth 20s. yearly if it be let."

Probably this will make some of the members, like the lady in *When Knights were Bold*, pine for the good old times.

In 1595, coal-mines in Arley, Bedworth, and elsewhere, are found in the possession of Sir Francis Willoughby, by grant from the Crown.

The Arbury account-book previously mentioned throws considerable light upon the methods of working in Warwickshire at the beginning of the seventeenth century. When a pit was to be sunk, an "earnest" of 1s. was paid to the sinkers. In one case, in December, 1603, a pit was sunk, and for the first 11 ells* 3s. per ell, and for the next 3 ells, 6s. per ell was paid. At this point it was necessary to drive a head to the water-pit, a distance of about 19½ feet, and this cost 19s. 6d. A further 6½ ells were sunk at 6s., and then the customary reward of 4d. was paid for hitting the Ryder coal; another 3 ells brought them through the stone or slate-coal, but here the water became troublesome, and they had to pay 2s. 6d. "for garlandinge the stone water into a corner of the pit." A further 2 ells at 6s. 8d. entitled the sinkers to 4d. for hitting the Seven-foot coal. This proves that they were in the absolute crop of the Coal-measures, and it is remarkable that the coal-seams now retain the names applied to them at so early a date. The pit-top was covered by a shed, in order that the men might work dry.

* An ell was equal to 45 inches.

The water seems to have been a considerable difficulty, the shafts occasionally running in, and this water was dealt with by means of "scopes," baling-engines, or gins, often worked by horses. They also had underground fire, as there are entries for filling up pits to damp the fire out; and in the year 1604, the colliers are said to have been "hindered with the dampe," but whether this means moisture or carbonic-acid gas is not clear.

The tools used consisted of mattocks, picks, mandrells, wedges, and shovels, the latter being of wood shod with iron, as may be seen in the examples belonging to the South Staffordshire and Warwickshire Institute of Mining Engineers. The colliers are said to have received "chalter payment" for getting the coals at the rate of 10d. the "three-quarters," the selling-price ranging from 2s. 6d. to 3s. for the same quantity, which is described in another part as "the ordinary load which moste do carry away." The profits were evidently not encouraging, as Sir John Newdigate seems to have ceased working—at least for a time—in the year 1610.

At this period Sir Thomas Beaumont was working mines at Bedworth, and his men and the miners at Griff had a prolonged and bitter quarrel; and then, water having accumulated, the Bedworth pits were abandoned. In 1619, some enterprising persons successfully undertook the recovery of the pits; and in 1622 some Coventry men obtained a lease, and started working at Griff. Sundry further quarrels took place, as the Bedworth men were accused of flooding the Griff pits, and the Coventry men were ordered to pay damages for injury to the meadows by allowing poisonous water from their pits to flow over them. Without following the many vicissitudes recorded, there is evidence that the Meryvale pits were working in 1654, and that there were several pits at Hawkesbury on lands belonging to the Coventry Corporation sometime later, when the price of coal was from 5½d. to 6d. per hundredweight. In the account-book for the year 1700, there is a project set out for sinking pits, and in 1711 there is a note of four pits on Sir Richard Newdigate's land, which were sunk about 90 feet apart to their full depth, and then worked from the bottom upwards. In 1723 there are entries of money for fire-engines for pumping water, and

these were evidently the Earl of Worcester's engines, improved by Capt. Savery. They were not used long, as in 1732 and following years men were paid for taking them down, and there are credits for the sale of parts. Matthias Dunn gives 1700* as the date of the first introduction of those engines for colliery-purposes at Griff; and engines are mentioned in this book at that date, but the writer is informed by an antiquarian that they are not the above fire-engines. James Watt, in a letter to Smeaton (1776), mentions an engine with cylinders 58 inches in diameter for Warwickshire, supposed then to be the most powerful in England, and it is believed to have been erected at Hawkesbury colliery.

In 1725, there were upwards of fifty collieries in Warwickshire, with a group of seven in the district of Wilnecote; in fact, they were extended along the whole outcrop on the eastern boundary. The pits were all shallow, and very limited in area, so that no trouble of any importance from explosive gas arose until the unfortunate explosion in 1882 at Baddesley colliery; but fortunately, there have been few disasters from this cause since that date. Progress was slow until early in the nineteenth century, when steam-power came into use. Fires from spontaneous combustion have been a great source of trouble in modern times, and much water has had to be dealt with in the sinkings. When the writer first commenced to act professionally in the district, nearly thirty years ago, the coal-trade was not flourishing, and the colliery with which he had to deal had lost a great amount of money. The coals were not considered of a high quality, principally, he thinks, because they had been obtained from near the outcrop, where they were of a soft and friable nature.

In 1881, the quantity of minerals raised was 1,133,419 tons, with 4,234 persons employed; but in 1906 the output had increased to 4,073,451 tons, with 13,209 persons employed, or nearly fourfold. In addition, as the coal has been followed into the deep, it has improved in quality, and has a good reputation, particularly in the London market, to which Warwickshire has the good fortune of being the nearest coal-field.

* *A Treatise on the Winning and Working of Collieries*, by Matthias Dunn, 1848, page 22; and second edition, 1852, page 11.

As the writer showed in his Presidential Address,* even now little more in all probability than the fringe of this important area has been developed.

A cordial vote of thanks was accorded to Mr. Alexander Smith for his interesting paper.

DISCUSSION OF PROF. CHARLES LAPWORTH'S PAPER ON "THE HIDDEN COAL-FIELDS OF THE MIDLANDS,"† AND OF MR. J. T. BROWNE'S PAPER ON "THE THICK COAL OF WARWICKSHIRE."‡

Mr. ALEXANDER SMITH (Birmingham), in opening the discussion, said that Prof. Lapworth's paper had been thoroughly discussed by the South Staffordshire members, but the members of The Midland Counties Institution of Engineers might have some observations to make. Mr. J. T. Browne's paper had been read at the meeting of The Institution of Mining Engineers in London, but unfortunately there were very few South Staffordshire men present; and, as their experience of working the Thick coal was necessarily extensive, he threw out a cordial invitation to those present that afternoon to join in the discussion. The views of the two districts as to the best method of working the Thick coal did not exactly agree, and South Staffordshire mining engineers would probably prefer the old system of rib-and-pillar working, whilst Warwickshire men preferred the system of working by three or four faces, taking probably the whole of the seams out together.

Mr. ELMSLEY COKE (Nottingham) referred to the probability of the South Staffordshire and Warwickshire coal-fields extending into the unproved area which separates them. He believed that geologists were more or less agreed that the whole of the Midland coal-fields were originally part of a large area, since broken up and denuded. The discovery of Upper Coal-measures in Nottinghamshire of a type similar to those found in Staffordshire, Lancashire, and North Wales, proved that during the later

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 82.

† *Ibid.*, vol. xxxiii., page 26. ‡ *Ibid.*, page 502.

period the existing barriers were not formed. He feared, however, that barren areas of older rocks would be found to exist between the Staffordshire and Warwickshire coal-fields.

In a lecture to the members of the National Association of Colliery Managers at University College, Nottingham, on October 26th, 1907, Prof. Clowes was reported to say that pyrites in the coal had nothing to do with gob-fires, the cause of spontaneous combustion being moisture in a porous coal. Other authorities took a different view, and this showed that further knowledge of gob-fires and their causes was required. Working these thick seams presented different problems in every pit. He thought that at Newdigate colliery the best plan was to obtain a reliable output from the Two-yard seam, working the other parts at a later period; continuing the experiments to work the entire seam. He considered Mr. Browne's paper of great value, and trusted that the discussion would elicit the opinion of those experienced workers of thick seams whom he saw around him.

Mr. Arthur Hall (Nuneaton) said that, after several years' experience in the working of the Warwickshire coal-seams, he was quite in agreement with the substance of Mr. Browne's paper.

Mr. Browne had stated that the retreating system in three lifts was not new. This was correct, as the method was introduced some twenty-five or thirty years ago at Charity colliery by the late Mr. Cunliffe, of Bedworth, and had been carried out there ever since. He noticed, however, that Mr. Browne did not mention this fact in his paper. It fell to his (the speaker's) lot to re-open and re-equip this colliery some two-and-a-half years ago, and the same system was followed, most of the heading being done by the Stanley double- and single-heading-machines. He thought that a great deal of the heading at Griff and Newdigate collieries must also have been done by these machines, although Mr. Browne did not mention it.

Apart from the question of gob-fires, to his mind one of the greatest drawbacks to the retreating system was the destruction of the level (out of which the hills are driven) as the faces approached it, often resulting in a large pillar of coal having to be left. This, however, could be obviated by driving other hills

from an upper level to the lower level, so as to come out in the latter exactly opposite the old hills, and get into line with them. This method practically enabled the whole of the coal to be got.

With regard to gob-fires and fires in pillars, he quite agreed with Mr. Browne's theories as to their origin, and also as to his method of treatment. During his experience in Warwickshire, he had enjoyed a remarkable immunity from them, and attributed this in great part to the system that he had followed of liberally interspersing the packs, and partly filling up the goaves with flue-dust, sand, and burnt pit-hill rubbish, which was specially sent down from the surface. It was less expensive than a big fire, and it must be borne in mind that it usually gravitated to the working-faces, where it was unloaded, and the tubs then filled out with coal. Moreover, the operation was less costly than might be imagined by those who had not tried it.

In conclusion, he must express himself as an advocate of the policy of leaving as few pillars as possible in the seams, and he believed in the quickest possible uniform advancement of the separate faces.

Prof. R. A. S. Redmayne (Birmingham) thought that the idea of spontaneous combustion being due to iron-pyrites was gradually dying out, for it had undoubtedly been proved that spontaneous combustion was not mainly due to its presence. The subject was a most interesting one, opening out a field for investigation which might well occupy the attention of some young man desirous of distinguishing himself in original research.

He referred to the fact that in the coal-seams of Northumberland and Durham, as also in those of South Wales, gob-fires were practically unknown, whilst in South Staffordshire and Warwickshire, where the Thick coal occurred, as well as in some thinner seams, they were quite common. In his opinion much might be said in favour of the theory that the porosity of the coal was largely responsible for the spontaneous fires which occurred in coal of that class, allowing as it did of more rapid absorption of oxygen. He gave particulars of observations made with two samples of coal—from Durham and South Staffordshire—submitted for a time to the action of the air. The coal from Durham had, if anything, shrunk, while that from South Staffordshire had expanded, and eventually fell to pieces,

a change due, no doubt, to its initial porosity, which probably explained its liability to spontaneous combustion. That was the conclusion also arrived at by the members of the South Staffordshire Institute at many of their recent discussions on the subject.

Mr. ALEXANDER SMITH (Birmingham) remarked that such was the conclusion of the South Staffordshire Institute thirty-two years ago, and that whenever the matter had again come forward the members had arrived at precisely the same conclusion. Iron-pyrites was of infinitesimal aid to spontaneous combustion.

Mr. F. A. GRAYSTON (Tamworth) said that he believed that the retreating system of working the Warwickshire Thick coal in three divisions was practised many years before the date named by Mr. Hall, as a Mr. Thomas Smith had written a book which came out so long ago as 1836,* in which he described his method of getting the Thick coal at Hawkesbury colliery in Warwickshire in 1829. He said that the headings were driven in the upper seams (Two-yard and Ell), which were worked in descending order. Headings were afterwards driven in the lowest seam (Slate-coal) and worked in the same way. According to the report, this method was fairly successful, but it was admitted that no slack was being worked at that time, only large coal and cobbles. A profit of 2s. 3d. to 2s. 6d. per ton was made, but at a time when the selling prices were high.

With regard to the chief question in Mr. Browne's paper, namely, the method of working, he thought that it was a matter of experience for each one. In the Cradley district, where the South Staffordshire Thick coal was being worked, he knew that both pillar-and-stall and longwall in two divisions were in operation, and in some instances even in the same pit. It depended principally upon whether the coal was free from thick dirt-partings or not; which drove them to the conclusion that they must decide on the method of working by the section of the coal passed through.

Mr. ISAAC MEACHEM (Blackheath, Birmingham) said that the method to be adopted in working the Thick coal depended entirely upon the nature of the seams. The nature of the Thick coal varied greatly, often in the same colliery. At a colliery

* *The Miner's Guide*, by Thomas Smith, 1836, pages 137 to 142.

with which he was acquainted, where the coal was practically laid down in one seam, they had worked it by the pillar-and-stall method; but a little further away the coal was broken into several seams, and in that case it was got by working the top seams first and the bottom seams afterwards. It was found impossible to adopt one uniform method, even at a single colliery, and practically every section of the colliery had to be considered on its own merits. This all tended to show how impossible it was to say by what method any of the Thick coal could be worked.

With regard to the use of carbonic-acid gas for extinguishing fires, he had at first looked favourably upon the suggestion; but, after a little experience, he had found that it could not be relied upon to put a fire out, as the carbon-dioxide only retarded the fire.

Mr. Arthur Sopwith (Cannock Chase) remarked that he had some experience of gob-fires. At a colliery in Austria with which he was connected at one time they were troubled a good deal with fires. It was found that in one part of the mine where they had fires, iron-pyrites was finely disseminated in the coal; but on the other side of the shaft the iron-pyrites was found in clusters, and in that portion of the mine they were free from fires. He thought that this went to show that the pyrites played some part in spontaneous combustion, possibly by the manner in which it occurred, that is, where finely disseminated. It was not, however, a primary but an auxiliary cause.

Mr. Laurence Holland (Birmingham) said that he would like to know whether the method of winning the Thick coal by taking off the top seam, as suggested by Mr. Browne, had been tried in Warwickshire, because he did not think that it would answer in the South Staffordshire district; for, if they were to remove the top seam, the bottom would lift, and they would very soon get fires. He thought that undoubtedly the best way to win Thick coal was by driving the roads either above or below the coal. At Hamstead colliery, it appeared that in whatever part of the seam they drove the roads, whether in the top, middle, or bottom of the coal, sooner or later they got fires on the corners of the bolt-holes, always on the return side. These fires could not be dammed off, but had to be dug out and the breaks heavily watered.

The difficulty of working Thick coal at an inclination had been mentioned. He had worked Thick coal with a considerable dip by the South Staffordshire "square-work" method, and thought that it was the nicest piece of coal he had worked. There was plenty of water to fill up the openings, and not much trouble from fires; but on the other side of the pit, where the seam was level, they had a large number of fires.

With regard to carbon-dioxide, he thought that it was useful for small fires in cases where it could be properly applied to the seat of the fire, but of no use for big fires, owing to the difficulty of concentrating it on the fire. He had used liquid carbon-dioxide at Hamstead colliery with success in a road in the Thick coal where fire was frequently breaking out in the coal at the side of a brick-and-sand dam. An air-tight door casing was erected about 60 feet from the dam, and cylinders of the liquid were liberated between the door and the dam periodically. This had the effect of cooling the face of the dam and filling the breaks in the coal with carbon-dioxide and considerably reducing the frequency of fires.

Mr. W. F. Clark (Walsall) said that it was impossible to lay down fixed rules or regulations for working the Thick coal of South Staffordshire, and he would give an example in support of this opinion. Mr. Holland had said that it would be impossible to work the Thick coal by taking the top off first. Now, at a colliery at Old Hill, with which he was connected, the way of working was to take the top-coal off first. If they did not, the coal was ground to slack, and often fired; in fact, they got all sorts of trouble. The thickness of the seam there was 32 feet. Their method was to take the top-coal off first, working in a modified form of longwall; after the top had been got, and a considerable period of rest allowed, they then drove out and worked the bottom-coal in exactly the same way. The first working had become consolidated and they had what was called a "second working." He mentioned this, as, even amongst Thick-coal men themselves, if they did not happen to have had experience of the whole of South Staffordshire, they were apt to come to wrong conclusions. They could depend upon it that in working these thick seams they could not lay down any golden rule, but must consider each seam as it existed. A committee had been appointed some time ago to inves-

tigate and lay down some fixed rule for working the Thick coal, but they would never be able to do it.

With regard to gob-fires, he was inclined to agree with Mr. Sopwith that pyrites had something to do with the matter, although he did not for one moment suppose that it was the sole cause. Many of the seams that fired spontaneously were those where there were large quantities of pyrites. He had known also a seam comparatively free from pyrites, which was absorbing oxygen quite as rapidly as a seam containing pyrites.

Mr. William Hay (Mansfield) expressed the opinion that props left in the gob were a contributory cause of gob-fires. He had used (with a certain amount of success) carbonic-acid gas for extinguishing fires. He thought that a face about 300 feet long should be worked in the Two-yard seam and two gate-roads carried (intake and return) by the ordinary longwall system, ripping the roof until the packs were buried. In this way he ventured to predict complete immunity from gob-fires in the main roads of the mine. The rest of the top-seam would be worked out by the retreating system through coal-headings. After settlement had taken place—say in five or six years—the lower seams could be safely worked. He was also of opinion that if the seams were worked successively, and not simultaneously, considerably more coal could be worked.

He noticed that Mr. Browne had apologized for the "see-saw" system of haulage. He (the speaker) thought that there was no need for apology, as he had used this method and found it to be more economical, and certainly as efficient, as the old main-and-tail system.

Mr. T. H. Bailey (Birmingham) thought that one of the reasons why some seams of coal were more subject to spontaneous combustion than others was the porousness of the coal, such as the thick seams of South Staffordshire and Warwickshire, which in their natural state are not so compressed as the thin seams of other districts in which spontaneous combustion did not occur. Where the whole of the Thick coal was taken out, enormous friction resulted, and thus produced conditions favourable to spontaneous combustion.

Mr. H. R. Hewitt (Derby) said that he desired to give a warning against the use of carbonic-acid gas in dealing with under-

ground fires, unless all precautions were taken to see that there was no possibility of workmen being poisoned. The gas might be applied to the back of a stopping through a pipe, if the stopping was kept air-tight, or it might be turned into a district of the mine, if men were removed from the return side; and in the latter case there was the possibility of a fall of roof in the air-way causing the carbonic-acid gas to back up against the intake. He only looked upon this remedy as being temporary, so as to enable work to proceed, after the fire had been held in check, for the building of more effective dams. It was a very common practice in France to send surface-stone into the mine to be used for effective packing, and at the Arnao mine in Spain, working coal 40 feet thick under the sea,* it was the common practice also; and it appeared to him that using a non-carbonaceous rock in a mine subject to fires would go a long way towards preventing a fire from starting in the goaf. Whence that rock came was a matter of detail, and in South Derbyshire the packs in the Main coal-seam were largely constructed of rock from the Eureka seam, so that gob-fires were nearly unknown. At Newdigate colliery large quantities of sand were sent into the mine from a surface-quarry; and it would be interesting to know what was the cost per week due to goaf-fires; the cost of quarrying rough stone for the purpose of supplying packing material would not exceed 3d. per ton. Mr. William Charlton had described a system† of working the Thick coal of Staffordshire in two sections, which perhaps Mr. Browne had seen. Seeing that the Two-yard coal was the most valuable, it might be advisable to work that seam only, and leave the other coals to be got at some future date. It was found desirable to leave 18 inches of roof-coal over the packs.

Mr. F. N. SIDDALL (Burton-upon-Trent) mentioned that to lessen the trouble of gob-fires, at the colliery with which he was connected the packs were constructed of rock, and had been so for some considerable time. For that purpose, every sixth "box" going down the pit was loaded with rock. The packs were made of rock and sand, and as they concluded that slack was the cause of gob-fires, all slack was filled out of the gob;

* Working a Thick Coal-seam at Arnao, Spain," by — Dach, *Trans. Inst. M. E.*, 1897, vol. xii., page 655.

† "A Method of Working the Thick Coal-seam in Two Sections," by William Charlton, *ibid.*, 1901, vol. xxi., page 264.

since then gob-fire cost had practically vanished. The rock had to be jigged several hundred yards of inclines, in some cases as great as 1 in 3. The packing was certainly more expensive, but they were now free from gob-fire.

Being acquainted with Lancashire collieries, in his opinion the reason for their freedom from gob-fires was the fact that all coal was filled with the shovel.

Mr. G. J. BINNS (Duffield) said it was remarkable that hardly two identical opinions could be found as to the origin of spontaneous combustion.

A recent report in the *Colliery Guardian** gave details of a meeting of the Berlin District Gas Association, at which a paper on the subject was read by Herr Heinrich Pohmer, and it was amusing to note how the members taking part in the discussion differed. Some said that air should be allowed to ventilate the slack coal, while others thought that it should be absolutely excluded; some maintained that the small coals were the exciting agent, and others argued to the contrary; all seemed, however, to be agreed that iron-pyrites played no appreciable part in the process.

It must also be remembered that, in making these experiments, the Germans had the advantage probably of every scientific appliance; that their experiments were carried on in the light of day; and that they had in this way great advantages over colliery managers, whose operations were hindered by the difficulties attendant on underground work.

He (Mr. Binns) had been under the impression that iron-pyrites had been excluded from the causes of spontaneous combustion for many years; and he might call attention, as he had already done more than thirty years ago, in a similar discussion, to the fact that iron-pyrites was not found in stacks of hay, which was probably more subject to spontaneous combustion than any known material.

In considering the causes of gob-fires, it seemed to him that the existence of extremely volatile gases, for example, xylol and toluol—which he understood took fire at extremely low temperatures—had been forgotten, and it was pointed out that even at a temperature much lower, he believed, than that of boiling water,

* 1907, vol. xciv., page 1004.

THE INSTITUTION OF MINING ENGINEERS.

EIGHTEENTH ANNUAL GENERAL MEETING,
HELD IN THE UNIVERSITY BUILDINGS, SHEFFIELD, SEPTEMBER 4TH, 1907.

MR. H. C. PEAKE, PAST-PRESIDENT, IN THE CHAIR.

Mr. J. R. R. WILSON (H.M. Inspector of Mines and President of the Midland Institute of Mining, Civil and Mechanical Engineers), in welcoming the members, introduced the Lord Mayor of Sheffield (Alderman Robert Styring), Mr A. J. Hobson, representing the University and the Chamber of Commerce, and Mr. W. F. Beardshaw, of the Engineering and Metallurgical Society.

The LORD MAYOR (Alderman Robert Styring), on behalf of the Corporation and Citizens of Sheffield, offered a cordial welcome to the members. Recent developments in connection with mining had been more extraordinary than in connection with any other industry in Great Britain, particularly with reference to the applications of electricity, and the results of the efforts made by this Institution in connection with the training of mining engineers were very patent and important. The decrease in the number of deaths from explosions in coal-mines had been very pronounced during the past twenty years. During the ten years, 1887-1896, the deaths from explosions in coal-mines were 1,505; and for the succeeding ten years, 1897-1906, the number had fallen to 602, so that there was an enormous diminution, arising from better management and from the fact that mining engineers and those connected with the industry were better qualified for the discharge of the duties devolving upon them than was the case in the earlier period. The diminution was, of course, greater than it seemed, inasmuch as the number of persons engaged in the industry during the last ten years must be considerably larger than in the former period. The number of deaths from this single cause had fallen from an average of 150 to an average of 60 per year, no less than 60 per cent. The preservation of life was the most important feature, but an explosion could not occur without causing great damage to the mine and loss to the proprietors, and if there were

fewer explosions, there was less loss attributable to that cause. Consequently, from the financial aspect, it was important that those who were engaged in carrying on the mining industry should be well and efficiently trained. He expressed the hope that the proceedings in connection with the annual meeting would be of the most satisfactory nature and promote the interests of the great industry which they all had so much at heart.

Mr. A. J. Hobson, on behalf of the Sheffield Chamber of Commerce, extended a hearty welcome to the members. Sheffield and the surrounding districts were largely concerned in coal-mining, which represented probably the preponderating mining industry of the country. The present high price of coal had an important bearing upon the industries of Sheffield; but they must make the best of the present situation, in the hope that demand and supply would adjust themselves without too serious suffering on the part of other industries. The removal of the export duty had undoubtedly stimulated the export of coal; and, without wishing to express any opinion as to the imposition of that tax, it was an illustration of what could be done to check the sale of a commodity by an impost for revenue-purposes and not intended to limit trade.

The Chairman (Mr. H. C. Peake) tendered the hearty thanks of the members to the Lord Mayor, Mr. Hobson and others for their kindly welcome to Sheffield. One of the advantages of high prices for fuel was that they conduced to economy in consumption, and when once these economies were effected they were continued.

ELECTION OF OFFICERS, 1907-1908.

The Secretary announced the election of officers for the ensuing year by the Council as follows:—

President.

Mr. C. E. Rhodes.

Vice-Presidents.

Mr. W. Armstrong.	Mr. R. McLaren.	Mr. J. Newton.
Mr. J. Ashworth.	Mr. G. May.	Mr. W. G. Phillips.
Mr. G. J. Binns.	Mr. J. H. Merivale.	Mr. J. G. Weeks.
Mr. T. Douglas.	Mr. T. W. H. Mitchell.	Mr. R. S. Williamson.
Mr. J. T. Forgie.	Mr. R. T. Moore.	Mr. J. R. R. Wilson.

AUDITORS.

Messrs. JOHN G. BENSON & SONS, Newcastle-upon-Tyne.

TREASURERS.

Messrs. LAMBTON & Co., The Bank, Newcastle-upon-Tyne.

Mr. J. J. TURNBULL (India) moved a vote of thanks to the retiring President, Vice-Presidents, Councillors and Officers for their services during the past year.

Mr. ROBERT CLIVE seconded the resolution, which was cordially adopted.

The SECRETARY read the Annual Report of the Council as follows:—

EIGHTEENTH ANNUAL REPORT OF THE COUNCIL.

The Institution of Mining Engineers comprizes the following societies: namely, the Manchester Geological and Mining Society; the Midland Counties Institution of Engineers; the Midland Institute of Mining, Civil and Mechanical Engineers; the Mining Institute of Scotland; the North of England Institute of Mining and Mechanical Engineers; the North Staffordshire Institute of Mining and Mechanical Engineers; and the South Staffordshire and Warwickshire Institute of Mining Engineers.

The progress of the membership since the formation of the Institution in 1889 is shown in the following table:—

Year ending July 31st.	No. of Honorary Members.	No. of Members.	No. of Non-federated.	Totals.
1890	0	1,189	50	1,239
1891	0	1,187	9	1,196
1892	14	1,401	19	1,434
1893	14	1,519	19	1,552
1894	13	2,055	123	2,191
1895	13	2,197	109	2,319
1896	13	2,288	81	2,382
1897	13	2,434	60	2,507
1898	13	2,449	47	2,509
1899	15	2,430	41	2,486
1900	15	2,432	35	2,482
1901	15	2,509	30	2,554
1902	15	2,556	30	2,601
1903	17	2,645	26	2,688
1904	17	2,742	22	2,781
1905	16	2,944	74	3,034
1906	17	2,972	73	3,062
1907	19	3,020	78	3,117

The Annual General Meeting of the Institution was held in Hanley on September 12th, 13th and 14th, 1906; and a General Meeting was held in London on June 13th, 14th and 15th, 1907. The thanks of the Institution have been sent to the owners of works, collieries, etc., which were thrown open to the members attending these meetings.

The influence of the Institution would become more effective, and the membership considerably increased, if members would direct the attention of non-members to the benefits to be derived from membership. A member of one of the federated institutes receives, in addition to the proceedings of his own institute, those of the six other federated institutes and of the meetings of The Institution of Mining Engineers.

Prizes have been awarded to the writers of the following papers, which are printed in the *Transactions* (vols. xxx. and xxxi.):—

"The Mining Fields of Southern Rhodesia in 1905." By Prof. J. W. Gregory.

"Practical Problems of Machine-mining." By Mr. Sam Mavor.

"Rescue-apparatus and the Experience gained therewith at the Courrières Collieries by the German Rescue-party." By Mr. G. A. Meyer.

"Description of the Sinking of Shafts through Sand at Ardeer, Ayrshire, by the Pneumatic Process, with Notes on the Subject of Caisson-ventilation and Sickness." By Mr. T. H. Mottram.

"Commercial Possibilities of Electric Winding for Main Shafts and Auxiliary Work." By Mr. W. C. Mountain.

"The Value of Fossil Mollusca in Coal-measure Stratigraphy." By Mr. J. T. Stobbs.

Addresses have been delivered during the year by Mr. Maurice Deacon, President of The Institution of Mining Engineers; by Mr. Charles Pilkington, President of the Manchester Geological and Mining Society; by Mr. J. R. R. Wilson, President of the Midland Institute of Mining, Civil and Mechanical Engineers; by Mr. John Newton, President of the North Staffordshire Institute of Mining and Mechanical Engineers; and by Mr. F. A. Grayston, President of the South Staffordshire and Warwickshire Institute of Mining Engineers.

The papers on geology include the following:—

"The Ozokerite (Mineral Wax) Mine of the Galizische Kreditbank, at Boryslaw, Galicia, Austria." By Mr. David Macdonald Chambers.

"Gypsum in Sussex." By Messrs W. J. Kemp and George Alfred Lewis.

"The Hidden Coal-fields of the Midlands." By Prof. Charles Lapworth.

"Notes on the Structural Geology of South Africa." By Dr. C. Sandberg.

"New Rand Gold-field, Orange River Colony." By Mr. Arthur Robert Sawyer.

"Deposits in a Pit-fall at Tanfield Lea, Tantobie, County Durham." By Dr. J. A. Smythe.

"Notes on Cauldon Low and the Manifold Valley, North Staffordshire." By Messrs. John Thomas Stobbs and Edward Brownfield Wain.

"The Rock-salt Deposits at Preesall, Fleetwood, and the Mining Operations therein." By Mr. Frederick J. Thompson.

"Gypsum, and its Occurrence in the Dove Valley." By Mr. T. Trafford Wynne.

Mining engineering has been the subject of the following papers:—

"C Pit, Monkwearmouth."

"Water-supplies by means of Artesian Bored Tube-wells." By Mr. Herbert F. Broadhurst.

"The Thick Coal of Warwickshire." By Mr. James Tardif Browne.

"Cast-iron Tubbing: What is its Rational Formula?" By Mr. Henry Wallace Gregory Halbaum.

"An Account of Sinking and Tubbing at Methley Junction Colliery, with a Description of a Cast-iron Dam to Resist an Outburst of Water." By Mr. Isaac Hodges.

"The Boultham Well at Lincoln." By Mr. William McKay.

"Sliding-trough Conveyors." By Mr. M. Malplat.

"Heading by Longwall Machines." By Mr. Sam Mavor.

"Polmaise Collieries." By Mr. James Salmond.

"Bowburn Winning." By Mr. Addison Langhorne Steavenson.

"The Importance of Scientific Mining in the Barnsley District." By Mr. R. Sutcliffe.

"Sinking through Magnesian Limestone and Yellow Sand by the Freezing-process at Dawdon Colliery, near Seaham Harbour, County Durham." By Mr. Ernest Seymour Wood.

The following papers have been contributed on mechanical engineering:—

"Hauling Arrangement at the Face."

"Improved Constructions of Rails and Rail-joints for Collieries, Mines and Quarries." By Mr. John Bentley.

"Notes on the Feed-water of Colliery-boilers." By Mr. Alfred Eardley Cooke.

"An Appliance for Automatically Stopping and Restarting Mine-wagons." By Prof. W. Galloway.

"Elliott Washer and Hardy Dust-extractor and Grinder." By Mr. Edward Greaves.

"The Hanley Cage Guardian." By Mr. Albert Hanley.

"The Most Suitable Form of Guides for Cages for Winding from Deep Shafts: 1,500 Feet and Deeper." By Mr. Augustus John Kennedy.

"A Rateau Exhaust-steam-driven Three-phase Haulage Plant." By Mr. William Maurice.

"Effects of Acceleration on Winding-torques, and Test of Tarbrax Electrical Winding-plant." By Mr. George Ness.

"The Most Suitable Form of Guides for Cages for Winding from Deep Shafts: 1,500 Feet and Deeper." By Mr. Norman Wilkinson Routledge.

"Boilers for Colliery Purposes." By Mr. Frederick Charles Swallow.

"A Diamond Hand-boring Machine." By Mr. John B. Thomson.

"Cage-lowering Tables at New Moss Colliery." By Mr. Thomas Herbert Wordsworth.

Electricity and its applications have been discussed in the following papers:—

"Cost of an Electrical Unit at a Colliery." By Mr. Percy C. Greaves.

"Recent Improvements in the Design of Electric Cables for Collieries." By Mr. George G. L. Preece.

"Electric Plant, Axwell Park Colliery." By Mr. Robert Rutherford.

"Walsall Corporation Electric Supply." By Mr. Sydney Leonard Thacker.

"Electric Transmission of Power at the Works and Collieries of the Grand Hornu, Belgium." By Mr. E. Troussart.

The following paper, which led to a lengthy discussion, was contributed on the subject of inland navigation:—

"Improvements required in Inland Navigation." By Mr. Henry Rodolph de Salis.

The occurrence of fires and the use of rescue-appliances have been described in the following papers:—

"Experimental Gallery at Altofts Collieries."

"Report on Rescue-work done by Men Wearing Rescue-apparatus in the Experimental Gallery at Messrs. Pope and Pearson's Collieries, Altofts, on March 23rd, 1907."

"The Pneumatogen: The Self-generating Rescue-apparatus, compared with other Types." By Mr. Richard Cremer.

"The Use and Care of Oxygen-breathing Apparatus." By Mr. Matthew Henry Habershon.

"A Gob-fire in a Shropshire Mine." By Mr. St. Victor Champion Jones.

"Liquid Air and its Use in Rescue-apparatus." By Mr. Otto Simonis.

The manufacture of coke and the utilization of waste-heat from coke-ovens are described in the following papers:—

"A Bye-product Coking-plant at Clay Cross." By Mr. William Birkenhead Mather Jackson.

"Notes on Bye-product Coke-ovens, with Special Reference to the Koppers Oven." By Mr. Albert Victor Kochs.

The following papers have been contributed on mine ventilation, mine-gases and colliery explosions:—

"The Courrières Explosion." By Mr. William Nicholas Atkinson, H.M. Inspector of Mines, and Mr. Albert Mayon Henshaw.

"Experiments Illustrative of the Inflammability of Mixtures of Coal-dust and Air." By Dr. Peter Phillips Bedson and Mr. Henry Widdas.

"Outbursts of Coal and Gas in the Cockshead Seam, Shelton Colliery." By Mr. Frank Ernest Buckley.

"The Application of Duplicate Fans to Mines." By the Rev. George Marie Capell.

"Treatment of Dust in Mines, Aboveground and Belowground." By Mr. Richard Harle.

"The Wolf Safety-lamp." By Mr. L. H. Hodgson.

"Acetylene Safety-lamps." By Mr. L. H. Hodgson.

"Tests of a Mine-fan." By Mr. John B. Thomson.

The miscellaneous papers comprize:—

"Memoir of the late Sir Lowthian Bell, Bart."

"A Stretcher for Use in Mines." By Mr. John F. K. Brown.

"Barometer, Thermometer, etc., Readings, for the Year 1906." By Mr. Percy Strzelecki.

"Memoir of the late John Daglish." By Mr. M. Walton Brown.

"The Cook Calorimetric Bomb." By Mr. Walter Henry Coleman.

"Ferro-concrete and its Applications." By Mr. T. J. Gueritte.

"The Valuation of Mineral Properties." By Mr. Thomas Aloysius O'Donahue.

"Electro-barograph for Mines." By Mr. B. H. Thwaite.

"A New Pocket-transit." By Mr. William Denham Verschoyle.

The foregoing lists demonstrate the varied nature of the papers (65) communicated during the past year and printed in the *Transactions* (vols. xxxii. and xxxiii.). The Council trust that members will continue to send in papers as liberally as heretofore. During the past year, "Notes of Papers (84) on the Working of Mines, Metallurgy, etc., from the *Transactions* of Colonial and Foreign Societies and Colonial and Foreign Publications," have been continued, and should prove of value to the members.

The Institution of Mining Engineers for many years has endeavoured by memorial to, and interview with, the Postmaster-general to obtain a reduction in the rates of postage on the *Transactions* of scientific and learned societies, in order that the present excessive difference between the cost of postage on weekly and periodical publications might be remedied. The postage on the *Transactions* of this Institution varies from 2½d. to 4d. per part, and the total cost is about £450 for 12 issues per annum, representing about 15 per cent. of the members' subscriptions. The Council urge that the cost of postage for the publications of scientific societies, as may be approved or registered by the Postmaster-general, shall be at the same rate as

registered newspapers. The British Science Guild, with Sir Alexander Pedler as honorary secretary, have undertaken the work of carrying on the agitation for reduced postage, and the Council trust that they may soon be able to report that the efforts of the Guild, supported by scientific and learned societies, have proved successful.

For many years past the *Transactions* of this Institution have been allowed to enter the United States of America free of customs duty, as a result of the interview, in 1898, between Mr. R. P. Rothwell (acting on behalf of this Institution) and the Collector of Customs at the Port of New York. Recently, however, duty at the rate of 25 per cent. was charged on a large package of *Transactions* forwarded to a gentleman in Michigan, and three smaller parcels forwarded to a member in California were also endorsed as liable to customs duty. After lengthy correspondence with the forwarding agents, custom house officials and the postal authorities, the Council are pleased to report that an official communication has been received from the Post-office Department at Washington, stating that under Section 38 of the existing regulations of the Treasury Department (Treasury Department Circular No. 17 of March 1st, 1907), customs officers are required to prepare mail entries for similar packages, noting thereon the fact that such packages contain articles which are probably free under Paragraph 501 of the Tariff Act of July 24th, 1907, which packages are then forwarded to the Postmaster at the place of delivery, to be delivered upon the execution of the oath prescribed by the Treasury Department. The Council hope, therefore, that no further trouble may be experienced by members resident in the United States of America in respect of customs duty; but in case duty should be charged, a protest should be made at once by the individual member, who should also advise the Secretary of this Institution, in order that the matter may be taken up at once with the customs house officials.

Mr. Arthur Sopwith, senior Past-President of the Institution, will represent the Institution on the governing body of the Imperial College of Science and Technology, London, for a period expiring in 1911.

Mr. J. A. Longden represented the Institution at the meeting of Delegates of Corresponding Societies of the British Associa-

tion for the Advancement of Science held in York, in August, 1906, and at Leicester in July and August, 1907.

Mr. Bennett H. Brough represented the Institution at the Congress of the International Association for Testing Materials held in Brussels in September, 1906, and his report of the proceedings has been printed in the *Transactions*.

Mr. G. E. Coke will represent the Institution at the centenary celebrations of the Geological Society of London, to be held on September 26th, 27th and 28th, 1907, and will present an address.

Mr. Hugh Johnstone, H.M. Inspector of Mines, has been elected an honorary member of the Institution during his term of office.

Members of the Institution of Mining Engineers may purchase copies, at privileged rates, of the *Transactions* of the following Corresponding Societies:—The Australasian Institute of Mining Engineers, the Canadian Mining Institute, and the Mining Society of Nova Scotia.

The thanks of the members are due to the North of England Institute of Mining and Mechanical Engineers, who have provided, as hitherto, free of charges, offices and stock-rooms, and other facilities, during the past year.

BOOKS, ETC, ADDED TO THE LIBRARY.

Annales des Mines de Belgique, Bruxelles. Vol. xi., No. 4; vol. xii., Nos. 1 and 2; and Tables Générales des Dix Premiers Volumes, 1896 to 1905.

Australasian Institute of Mining Engineers, Melbourne. Transactions, vol xi.

British Association for the Advancement of Science, London. Report of the Seventy-sixth Meeting, held at York in August, 1906.

British Society of Mining Students, Bristol. Journal, vol. xxviii., Nos. 1-6.

Chemical, Metallurgical and Mining Society of South Africa, Johannesburg. Journal, vol. vi., Nos. 11 and 12; and vol. vii., Nos. 1-12.

Cory Brothers & Company, Limited, Cardiff. British Coal and Freight Circular and General Export List, August 31st, 1906, to July 31st, 1907.

Cuerpo de Ingenieros de Minas del Perú, Lima. Boletín, Nos. 37-40, 42 and 43.

Engineering and Mining Journal, New York City. Vol. lxxxii., Nos. 6-26; vol. lxxxiii., Nos. 1-26; and vol. lxxxiv., Nos. 1-5.

Engineering Times, London. Vol. xvi., Nos. 184-202; vol. xvii., Nos. 203-228; and vol. xviii., Nos. 229-235.

Franklin Institute of the State of Pennsylvania, Philadelphia. Journal, vol. clxii., Nos. 2-6; vol. clxiii., Nos. 1-6; and vol. clxiv., No. 1.

Geological Institution of the University of Upsala, Upsala. Bulletin, vol. vii., Nos. 13 and 14.

Institution of Mining and Metallurgy, London. Transactions, vol. xv.

Massachusetts Institute of Technology, Society of Arts, Boston. Technology Quarterly, vol. xix., Nos. 2-4; and vol. xx., Nos. 1 and 2.

Mining Society of Nova Scotia, Halifax. Transactions, vol. x.

New South Wales, Department of Mines, Sydney. Annual Report, 1906.

New Zealand, Department of Mines, Wellington. Annual Report, 1906.

Queensland, Department of Mines, Brisbane. Annual Report, 1906.

Queensland Government Mining Journal, Brisbane. Vol. vii., Nos. 73-79; and vol. viii., Nos. 80-85.

South Wales Institute of Engineers, Cardiff. Proceedings, vol. xxv., Nos. 1-4.

United States, Geological Survey, Washington. Annual Reports, 1905-1906.

—, —, —. Bulletin, Nos. 275-308.

—, —, —. Mineral Resources of the United States, 1905.

—, —, —. Monographs, No. 1.

—, —, —. Professional Papers, Nos. 46-55.

—, —, —. Water-supply and Irrigation Papers, Nos. 155-194.

EXCHANGES.

Annales des Mines de Belgique.
Australasian Institute of Mining Engineers.
British Association for the Advancement of Science.
British Society of Mining Students.
*Canadian Mining Institute.
Chemical, Metallurgical and Mining Society of South Africa.
Cuerpo de Ingenieros de Minas del Perú.
Franklin Institute of the State of Pennsylvania.
Geological Institution of the University of Upsala.
*Geological Survey of Canada.
*Institution of Mechanical Engineers.
Institution of Mining and Metallurgy.
*Lake Superior Mining Institute.
*Maryland Geological Survey.
Massachusetts Institute of Technology.
Mining Society of Nova Scotia.
*Missouri, Bureau of Geology and Mines.
New South Wales, Department of Mines and Agriculture, Geological Survey.
*North-east Coast Institution of Engineers and Shipbuilders.
*Revue Universelle des Mines, de la Métallurgie, etc.
*Rugby Engineering Society.
*Sociedad Nacional de Mineria de Chile.
South Wales Institute of Engineers.
*Transvaal, Department of the Mining Commissioner.
United States Geological Survey.

* No publications received during the current year.

July 31st, 1907.

Dr. THE TREASURERS IN ACCOUNT WITH

FOR THE YEAR

July 31, 1907.	£ s. d.	£ s. d.
To Balance, from last year, made up as follows :—		
Investment with River Tyne Commission	1,000 0 0	
Balance at Bank, Current Account	170 17 5	
" " Deposit Account	731 6 1	
" in Cashier's hands	5 7 3	
		1,907 10 9
To Subscriptions for the Year ending July 31st, 1905—		
Federated—		
South Staffordshire and Warwickshire Institute of Mining Engineers	1 18 0	
		1 18 0
Non-federated—		
Manchester Geological and Mining Society	9 0 0	
Added during year	1 0 0	
		10 0 0
To Subscriptions for the Year ending July 31st, 1906—		
Federated—		
Manchester Geological and Mining Society	66 10 0	
Midland Counties Institution of Engineers	13 6 0	
Midland Institute of Mining, Civil and Mechanical Engineers	4 15 0	
Mining Institute of Scotland	2 17 0	
North of England Institute of Mining and Mechanical Engineers	118 15 0	
North Staffordshire Institute of Mining and Mechanical Engineers	23 15 0	
South Staffordshire and Warwickshire Institute of Mining Engineers	53 4 0	
		283 2 0
Non-federated—		
Manchester Geological and Mining Society	3 0 0	
Added during year	1 0 0	
		4 0 0
To Subscriptions for the Year ending July 31st, 1907—		
Federated—		
Manchester Geological and Mining Society	174 16 0	
Midland Counties Institution of Engineers	304 19 0	
Midland Institute of Mining, Civil and Mechanical Engineers	325 17 0	
Mining Institute of Scotland	485 9 0	
North of England Institute of Mining and Mechanical Engineers	1,159 19 0	
North Staffordshire Institute of Mining and Mechanical Engineers	143 9 0	
South Staffordshire and Warwickshire Institute of Mining Engineers	85 10 0	
		2,679 19 0
Non-federated—		
Manchester Geological and Mining Society	25 0 0	
Mining Institute of Scotland	8 0 0	
		33 0 0
Carried forward		£4,919 9 9

THE INSTITUTION OF MINING ENGINEERS. **Cr.**

ENDING JULY 31, 1907.

July 31, 1907.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
By Printing—												
Transactions, vol. xxviii., printing	45	5	5									
" " " plates ...	0	15	0									
				46	0	5						
" " xxix., printing	102	3	8									
" " " plates ...	76	17	6									
				179	1	2						
" " xxx., printing	222	0	2									
" " " plates ...	52	11	11									
				274	12	1						
" " xxxi., printing	294	8	6									
" " " plates ...	87	9	6									
				381	18	0						
" " xxxii., printing	449	12	0									
" " " plates ...	268	4	11									
				717	16	11						
" " xxxiii., printing	199	8	0									
" " " plates ...	52	1	8									
				251	9	8						
							1,850	18	3			
Excerpts, vol. xxix.				5	2	0						
" " xxx.				15	18	9						
" " xxxi.				49	8	0						
" " xxxii.				67	2	2						
" " xxxiii.				21	0	7						
							158	11	6			
Proofs of Papers for General Meetings							20	7	3			
Circulars							14	0	7			
										2,043	17	7
" Addressing *Transactions*, etc.							69	1	0			
" Postages—Circulars				6	6	10						
" " Correspondence				20	15	2						
" " *Transactions*				548	1	3						
							575	3	3			
" Stationery, etc.							71	6	1			
" Insurance of *Transactions*, etc.							5	5	9			
" Binding—Library				2	1	5						
" " Sundries...				0	5	0						
" " *Transactions*				32	1	1						
							34	7	6			
" Reporting of General Meetings							31	9	6			
" Expenses of General Meetings							29	9	0			
Carried forward							£816	2	1	£2,043	17	7

Dr. THE TREASURERS IN ACCOUNT WITH

	£	s.	d.	£	s.	d.	£	s.	d.
Brought forward							4,919	9	9
To Local Publications and Authors' Copies—	1905-1906.			1906-1907.					
The Institution of Mining Engineers	0	10	6	68	4	10			
Manchester Geological and Mining Society £19 2 6									
Less allowance 1 12 6	17	10	0	28	10	1			
Midland Counties Institution of Engineers ...	0	0	0	1	5	2			
Midland Institute of Mining, Civil and Mechanical Engineers	0	0	0	11	1	10			
Mining Institute of Scotland	0	0	0	6	9	4			
North of England Institute of Mining and Mechanical Engineers	0	0	0	24	0	1			
North Staffordshire Institute of Mining and Mechanical Engineers	0	0	0	0	0	0			
South Staffordshire and Warwickshire Institute of Mining Engineers	0	0	0	0	19	6			
	18	0	6	140	10	10			
							158	11	4
To Sales of Transactions, etc.—	1905-1906.			1906-1907.					
The Institution of Mining Engineers	3	6	6	125	8	6			
Manchester Geological and Mining Society ...	0	2	11	8	11	1			
Midland Counties Institution of Engineers ...	0	0	0	9	6	3			
Midland Institute of Mining, Civil and Mechanical Engineers	0	0	0	7	5	3			
Mining Institute of Scotland	0	0	0	7	5	3			
North of England Institute of Mining and Mechanical Engineers	4	0	0	46	1	3			
North Staffordshire Institute of Mining and Mechanical Engineers	0	0	0	16	6	3			
South Staffordshire and Warwickshire Institute of Mining Engineers	4	13	8	13	6	3			
	12	3	1	233	10	1			
							245	13	2
To Advertizements (*less* commission)				621	17	9			
To Address Labels				4	6	6			
To Interest on Deposit Account				30	11	11			
To Income from Investments				38	0	0			
							694	16	2
							£6,018	10	5

THE INSTITUTION OF MINING ENGINEERS.—*Continued.* **Cr.**

				£	s.	d.	£	s.	d.
Brought forward				816	2	1	2,043	17	7
By Incidental Expenses				23	19	5			
„ Salaries, Wages, Auditing, etc.				794	3	8			
„ Indexing *Transactions*				58	15	6			
„ Travelling Expenses				15	5	0			
							1,708	5	8
By Translations of Papers				12	10	6			
„ Abstracts of Foreign Papers, vol. xxix.	30	9	10						
„ „ „ „ xxx.	27	10	0						
				57	19	10			
„ Barometer Readings, etc.				1	18	6			
„ Calendars				18	7	6			
„ Prizes for Papers, vols. xxvi. and xxvii.	5	0	0						
„ „ „ xxx. and xxxi. ...	11	5	0						
				16	5	0			
							107	1	4
By Furniture				34	6	5			
„ Rates and Taxes				0	8	10			
„ Rent				7	10	0			
							42	5	3
							3,901	9	10
By Adjustment of Excerpts:—									
Manchester Geological and Mining Society				4	2	5			
Mining Institute of Scotland				3	12	2			
							7	14	7
By Balance made up as follows:—									
Investments with River Tyne Commissioners ...				1,000	0	0			
Balance at Bank, Current Account				205	1	10			
„ „ Deposit Account, including Interest				884	18	0			
„ in Cashier's hands				19	6	2			
							2,109	6	0
							£6,018	10	5

We have examined the above account of receipts and payments, with the books and vouchers relating thereto, and certify that in our opinion it is correct.

JOHN G. BENSON & SONS,
Chartered Accountants.

Newcastle-upon-Tyne,
August 10*th*, 1907.

THE INSTITUTION OF
BALANCE SHEET.—

Liabilities.

	£ s. d.	£ s. d.
July 31, 1907.		
Sundry Creditors—		
Advertisements paid in Advance	21 6 3	
Printing, etc.	1,160 0 0	
Postage of Transactions	175 0 0	
Abstracts of Foreign Papers in Volumes xxxi., xxxii., and xxxiii.	93 15 0	
Barometer Readings	13 5 0	
Prizes for Papers in Volumes xxx., xxxi., xxxii., and xxxiii.	48 15 0	
Indexing Volumes xxxi., xxxii., and xxxiii.	63 0 0	
		1,575 1 3
Balance of Assets over Liabilities, exclusive of the Value of the Stock of *Transactions*, etc.		969 13 7
		£2,544 14 10

We have examined the above Balance Sheet, with the books and vouchers relating thereto, and certify that in our opinion it exhibits a correct view of the affairs of the Institution.

JOHN G. BENSON & SONS,
Chartered Accountants.

Newcastle-upon-Tyne,
February 25th, 1908.

MINING ENGINEERS.

JULY 31, 1907.

Assets.

July 31, 1907.	£	s.	d.	£	s.	d.
Balance at Bank, Current Account	205	1	10			
" ", Deposit Account, including Interest	884	18	0			
" in Cashier's hands	19	6	2			
Investment with River Tyne Commission	1,000	0	0			
" " ", Interest to date	11	2	9			
				2,120	8	9
Subscriptions for the Year ending July 31, 1905, Unpaid—						
Non-federated—						
Manchester Geological and Mining Society	2	10	0			
				2	10	0
Subscriptions for the Year ending July 31, 1906, Unpaid—						
Non-federated—						
Manchester Geological and Mining Society	4	0	0			
				4	0	0
Subscriptions for the Year ending July 31, 1907, Unpaid—						
Federated—						
Manchester Geological and Mining Society	19	0	0			
Midland Counties Institution of Engineers	19	19	0			
Midland Institute of Mining, Civil and Mechanical Engineers	7	12	0			
Mining Institute of Scotland	4	15	0			
North of England Institute of Mining and Mechanical Engineers	94	1	0			
North Staffordshire Institute of Mining and Mechanical Engineers	18	1	0			
South Staffordshire and Warwickshire Institute of Mining Engineers	25	13	0			
				189	1	0
Non-federated—						
Manchester Geological and Mining Society	6	10	0			
Mining Institute of Scotland	0	10	0			
				7	0	0
Local Publications and Authors' Copies, Unpaid—						
Institution of Mining Engineers	0	15	4			
Midland Institute of Mining, Civil and Mechanical Engineers	3	6	7			
Mining Institute of Scotland	1	2	2			
				5	4	1
Transactions Sold, Unpaid—						
Institution of Mining Engineers	0	2	6			
Midland Counties Institution of Engineers	8	19	0			
North of England Institute of Mining and Mechanical Engineers	2	0	0			
North Staffordshire Institute of Mining and Mechanical Engineers	7	19	0			
South Staffordshire and Warwickshire Institute of Mining Engineers	8	15	8			
				27	16	2
Advertizements, Unpaid				188	14	10
				£2,544	14	10

THE LOCAL INSTITUTES IN ACCOUNT WITH THE INSTITUTION OF MINING ENGINEERS, FOR THE YEAR ENDING JULY 31ST, 1907.

Dr.	No. of Members.		Balance due at the beginning of the year.	Amounts falling Due during the Year.			
	Federated.	Non-federated.		Calls made during the year.	Excerpts.	Transactions, etc.	Totals.
			£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Manchester Geological and Mining Society	204	63	97 15 5	225 6 0	28 10 1	17 1 1*	368 12 7
Midland Counties Institution of Engineers	342	...	13 6 0	324 18 0	1 5 2	18 5 3	357 14 5
Midland Institute of Mining, Civil and Mechanical Engineers	351	...	4 15 0	333 9 0	14 8 5	7 5 3	359 17 8
Mining Institute of Scotland	516	17	2 17 0	498 14 0	7 11 6	7 5 3	516 7 9
North of England Institute of Mining and Mechanical Engineers	1,320	...	122 15 0	1,254 0 0	24 0 1	48 1 3	1,448 16 4
North Staffordshire Institute of Mining and Mechanical Engineers	170	...	23 15 0	161 10 0	0 0 0	24 5 3	209 10 3
South Staffordshire and Warwickshire Institute of Mining Engineers...	117	...	59 15 8	111 3 0	0 19 6	22 1 11	194 0 1
Totals	3,020	80	324 19 1	2,909 0 0	76 14 9	144 5 3	3,454 19 1

Cr.	Amounts Paid during the Year.					Balance due at July 31st, 1907.
	Balance from previous years.	Calls.	Excerpts.	Transactions, etc.	Totals.	
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Manchester Geological and Mining Society	97 15 5†	199 16 0	28 10 1	10 11 1*	336 12 7	32 0 0
Midland Counties Institution of Engineers	13 6 0	304 19 0	1 5 2	9 6 3	328 16 5	28 18 0
Midland Institute of Mining, Civil and Mechanical Engineers	4 15 0	325 17 0	11 1 10	7 5 3	348 19 1	10 18 7
Mining Institute of Scotland	2 17 0	493 9 0	6 9 4	7 5 3	510 0 7	6 7 2
North of England Institute of Mining and Mechanical Engineers	122 15 0	1,159 19 0	24 0 1	46 1 3	1,352 15 4	96 1 0
North Staffordshire Institute of Mining and Mechanical Engineers	23 15 0	143 9 0	0 0 0	16 6 3	183 10 3	26 0 0
South Staffordshire and Warwickshire Institute of Mining Engineers	59 15 8	85 10 0	0 19 6	13 6 3	159 11 5	34 8 8
Totals	324 19 1	2,712 19 0	72 6 0	110 1 7	3,220 5 8	234 13 5

* Including arrears of calls falling due after July 31st, 1906.

† Including allowance of £1 12s. 6d. on account of Excerpts.

The PRESIDENT (Mr. C. E. Rhodes), in taking the Chair, thanked the members for the high honour which they had conferred upon him. It was nearly twenty years since the Institution first visited Sheffield. At that time he was President of the Midland Institute of Mining, Civil and Mechanical Engineers, and the federation of the various institutions was in its infancy. Very great strides had been made since then, and mining engineers generally would admit that great good had resulted from the federation of the various Institutes, which had then been recently brought about. Meetings in different districts had been held from time to time, and the exchange of ideas between the institutes had undoubtedly brought prominently before individual members knowledge that had been obtained by the researches of not only their own local institute, but of members of other Societies; and that knowledge had resulted in materially improving and increasing the safety of the large population which was now employed in the mines of this country, and for which mining engineers and colliery managers were responsible. The legislation which had conduced to the enactment of improved rules in connection with mining operations had to a great extent been initiated by the researches, investigations, and labours of their institutes. He sincerely hoped their deliberations would show that The Institution of Mining Engineers was not standing still, but progressing; and he would do all in his power to further its progress.

REPORT OF THE DELEGATE TO THE CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, LEICESTER, 1907.

The report of Mr. J. A. Longden, representing the Institution, was read as follows:—

STANTON-BY-DALE,
NOTTINGHAM,
August 6th, 1907.

TO THE PRESIDENT AND COUNCIL OF
THE INSTITUTION OF MINING ENGINEERS.

GENTLEMEN,

I attended the Conference of Delegates at Leicester to-day, there being about fifty members present, a much larger number than usual. The meeting was presided over by Mr. H. J. Mackinder, who delivered an Address on "The Advancement of Geographical Science by Local Scientific Societies." In the

course of his Address, he stated that in France there are some twenty local geographical societies, which hold an annual conference, and many valuable local geographical studies have emanated from these societies. The same is also true of Germany.

Mr. Mackinder urged the study of local land forms, local drift geology, local climate, etc., and the collection of information bearing on these subjects, with a view to its adequate mapping. As a matter of experience, only persons of special geographical training could accomplish the desired result, and he suggested that each society undertaking a share of the work should either find or have trained a leader whose special function it should be to correlate from a geographical point of view the work of the various specialists, and to draw deductions from his correlation for the guidance of the specialists in their further work. Local investigation would thus be co-operative, and the results would be synthetic. Sidelights would be thrown on all manner of special studies, and incidentally geographical and other teaching in the local schools would be placed on a sound "home" basis. The thorough geographical description of our country as a whole is impossible until this local spade work has been done uniformly through the country.

Dr. Theodore Groom wrote that the committee of Section C (Geology) had decided to recommend to the corresponding societies that the local work connected with the Section should embrace the following:—(1) Further investigations on drift; (2) the watching of new sinkings and borings, and the examination of cores; (3) the collecting of local terms applicable to geology and geography.

Mr. W. Whitaker supported this recommendation, and especially solicited the aid of provincial societies in recording the meaning of local terms applied to geological objects.

I made no comment with regard to Mr. Groom's recommendations, but consider that when a person has expended the sum of, say, £5,000 in putting down a bore-hole, he is not generally very anxious for everyone to know what he has discovered.

I am, Gentlemen,

Yours truly,

J. A. LONGDEN.

Mr. Robert Clive read the following paper on "The Sinking of Bentley Colliery":—

THE SINKING OF BENTLEY COLLIERY.

BY J. W. FRYAR AND ROBERT CLIVE.

Bentley colliery, the property of Messrs. Barber, Walker and Company, is situated 2½ miles north of Doncaster, on the western side of the Great Northern main line of railway. The shafts are situated in the centre of the royalty, and practically the whole area is covered with a thick layer of quicksand.

The Coal-measures and the Barnsley coal-seam were proved by the Bentley bore-hole (Table I.) in 1893.

TABLE I.—SECTION OF STRATA IN THE BENTLEY BORE-HOLE.

No.	Description of Strata.	Thickness of Strata. Feet.	Depth from Surface. Feet.
1	Alluvial deposits: quicksand	50	50
2	Trias: sandstones and marls	115	165
3	Permian: limestone and marls	335	500
4	Coal-measures: to Barnsley coal-seam ...	1,347	1,847

The site of the bore-hole is close to the present shafts.

Sinking of No. 2 Pit.—It was decided to sink through the 50 feet of quicksand, by lowering bolted cast-iron tubbing, together with steel piles, grooved and tongued into each other, forming a complete circle round the outside of the bottom ring, and sliding on the back. The piles were pushed downward by pressure applied against the bottom flange of the bottom ring; the tubbing was then lowered down, sliding inside the piles, and additional rings of tubbing were added at the top. The tubbing was supported at the top by screws, with cast-steel shoes bolted to the top ring. The shoes were attached to vertical girders built into the sides of a cement-concrete block: 6 feet thick, 50 feet square, and pierced with a hole, 23 feet in diameter, in the centre. The tubbing, 20 feet in inside diameter, 6 inches wide on the bed, and 1 inch thick, was fitted with inside flanges and bolted together with bolts, ⅞ inch in diameter. The piles, 72 in number and 8 feet long, were built of mild steel-plates, with a total

thickness of $1\frac{1}{4}$ inches. The sinking of No. 2 pit was started on October 9th, 1905, and a depth of 50 feet was attained in December, 1905. According to the bore-hole, the Triassic sandstone should have been reached at this depth, but, as nothing but quicksand was met with, a bore-hole was put down in the pit-bottom, and the Triassic sandstone was found at a depth of 100 feet instead of 50 feet. It was then decided to stop sinking, as the tubbing was not circular and several of the plates had been cracked.

A start was again made from the surface, outside the pit, 20 feet in diameter, with a pit, 23 feet in diameter, and with stronger tubbing and piles: several additions and alterations being made to the original scheme.

Tubbing.—The segments of tubbing, A, 1 foot 9 inches deep, $8\frac{1}{2}$ inches wide on the bed and $1\frac{1}{2}$ inches thick, were bolted together with sheeting, $\frac{3}{8}$ inch thick, between each joint. There were twelve segments in each ring, and each ring was stayed diagonally with four tie-rods, *k*, $1\frac{1}{4}$ inches in diameter.

The top ring of tubbing was supported by twelve steel screws, *l*, $2\frac{1}{4}$ inches in diameter, each fitted into a shoe, *m*, bolted to the top, at equal distances apart. The screws passed through compound girders B and C, laid on timber packings, D, across the top of the cement-concrete block, dividing the pit into four equal parts (figs. 1 and 2, plate viii.).

Steel Piles.—The piles, 18 feet long, were grooved and tongued into each other and built of mild-steel plates, *a*, *b*, and *c*, and *f*, *g*, and *h*, with a T iron, *d*, 8 by 4 inches on the back: the whole being bolted together with countersunk bolts, *e*, 9 inches apart (figs. 4, 5, and 6, plate viii.). Each pile had a T slot, *i*, in the centre, down the whole of its length, to allow of a T bolt being inserted through the holes in the segments to keep the piles close to the back of the tubbing. Two holes, *j*, $1\frac{9}{16}$ inches in diameter, were drilled between each pair of countersunk bolts, *e*, for the insertion of plugs when jacking. These holes were only drilled through the three plates, and not through the T bar at the back. Ninety-six piles formed a complete circle, 24 feet 5 inches in inside diameter, fitting closely against the back of the tubbing.

Guide-ring.—A strong cast-iron guide-ring (fig. 7, plate viii.) is fitted inside the piles, below the tubbing: this ring being always jacked down on to the sand immediately after excavating, so as to keep it as near to the toes of the piles as possible and to prevent them from leading in. The ring was built of twelve segments, 2 feet 6 inches deep, 12 inches wide on the bed and $1\frac{1}{2}$ inches thick, bolted together at each joint, without sheeting, with steel bolts, $1\frac{1}{4}$ inches in diameter. The segments were machined on their ends; and four tie-rods, $1\frac{1}{2}$ inches in diameter, were fastened, in the same manner as in the tubbing. Steel T bars, bolted to the back of the ring, fitted into the slots in the piles.

Rings of tubbing, built upon this guide-ring, were lifted by hydraulic jacks, and bolted to the lowest ring of the tubbing: the space taken up by the sheeting, $\frac{3}{8}$ inch thick, being sufficient to allow the last segment to be put in from the front.

The guide-ring was put together in position on balks laid across the top of the shaft, and the steel piles were fitted in. It was then lowered down to the bottom of the piles. The guide-ring weighed 17 tons; the piles, 1 ton each; and a ring of tubbing, $8\frac{3}{4}$ tons.

Figs. 1, 2 and 3 (plate viii.) show the general arrangement of the piles, the tubbing, and the guide-ring. The piles were first jacked down, the sand excavated, and the guide-ring jacked down. A ring of tubbing was then put on and bolted up, the tie-rods put in, and the iron dowels driven into the dowel-holes at each vertical joint. The guide-ring was always jacked down far enough, before a ring of tubbing was put on, so as to leave sufficient space for jacking the piles, after the ring had been fixed. This was done, so as to enable any piles to be immediately jacked down, in case there was a sudden rush of sand at any point.

Sinking was commenced on March 3rd, 1906. After nine rings of tubbing had been put on, the cement-concrete block commenced to break up and sink. The tubbing was kept as nearly vertical as possible by packing up the girders at the pit-top. The screws were kept tight on the low side and slack on the high side of the tubbing.

During the sinking, rushes and blowers of sand frequently occurred. Deep blow-holes formed themselves, and generally

silted up in a few days; but it was not usual to have more than two or three deep holes in the pit-bottom at one time. In one hole, when the pit was 40 feet deep, a pipe, 3 inches in diameter, was lowered downward, 32 feet, by its own weight. In one case, the pit-bottom rose 6 feet in about 30 minutes. At another time, although there was no large rush, sand was excavated, corresponding to a depth of 4½ feet, but the bottom was only lowered 6 inches.

The guide-ring gradually required more power to push it down inside the piles; and, at a depth of 50 feet, one of the

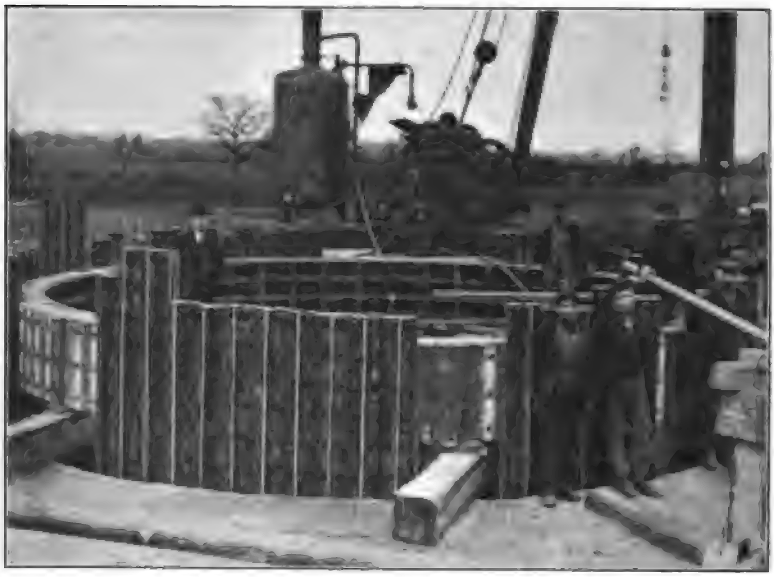

FIG. 12.—PILES AND GUIDE-RING AT NO. 2 PIT.

segments cracked in the ribs. The diameter inside the piles varied from 24 feet 4 inches to 24 feet 8 inches. At a depth of 51½ feet, the floating ring could not be jacked downward any further, owing to several of the piles, which were 6 feet into the sand, being bent inwards at the bottom.

After an unsuccessful attempt to push back the toes of the piles to a true circle, two rings of tubbing, 20 feet in diameter, were set on planks, laid across the bottom of the pit, and puddled

clay was rammed in between the tubbing and the piles. The piles were thereupon all jacked back about 5 feet. It then became possible to jack down the guide-ring.

From 50 to 80 feet deep, the water-feeder gradually increased from 100 to 400 gallons per minute; and, at the latter depth, considerable difficulty was experienced in pumping the feeder, owing to the head being too great for the aquathruster pumps in a single lift. They did not work satisfactorily in series: the quantity of sand frequently blocking up the pipes. Two Evans sinking pumps (with steam cylinders, 24 inches in diameter; rams, 16 inches in diameter and 24 inches stroke) were hung from a temporary headgear, supported on the top of the tubbing, which now no longer required holding at the top, owing to the friction of the ground on the back of it.

At a depth of 80 feet, the guide-ring was cracked in several additional places, and pressed more out of shape. The piles were then jacked down 6 to 8 feet below the guide-ring, and the remaining 15 feet of sand, clay, gravel, and large boulders, was sunk by pushing down rings, 20 feet in diameter, of bolted tubbing, by hydraulic jacks set between the top ring and girders laid across the guide-ring of the tubbing, 23 feet in diameter.

The top of the Triassic sandstone was reached at a depth of 100 feet on June 6th, 1906. The feeder of water at this depth was 600 gallons per minute. The total time occupied in sinking, from the surface to the sandstone, was 13½ weeks.

Nos. 7 and 8 aquathruster pumps were used down to a depth of 85 feet. These pumps worked satisfactorily until a depth of 80 feet was attained, under very trying conditions: pumping several tons of sand daily with the water. The Evans pumps worked satisfactorily below this depth, but the buckets required frequent changing.

For jacking the piles and the guide-ring, hydraulic ship-jacks of 20 tons, 30 tons, and 50 tons respectively, were used, according to the pressure required. Two travelling cranes (a crane with a jib 25 feet long to lift 3 tons, and a crane with a jib 42½ feet long to lift 5 tons) worked one on each side of the pit.

The total subsidence of the cement-concrete block at the surface was as follows: the north-eastern corner, 19 feet: the north-

western-corner, 6½ feet; the south-western corner, 5 feet; and the south-eastern corner, 12 feet. At the same time, the tubbing sank 11 feet 9 inches. Levels of the top ring of the tubbing and of the cement-concrete block, measurements from 12 side-lines hung round the tubbing from the top, and the diameters of the guide-ring, were taken every three hours, night and day, during the whole time that the work was in progress.

The first crib-bed was made at a depth of 113 feet in Triassic sandstone and the tubbing, 20 feet in diameter, was carried up to the surface.

Cement-concrete, *a*, was then laid on the top of the broken block, which was, finished off, 55 feet square, and 5 feet above ground-level. The pitchpine sinking headgear was erected on four brick-pillars, *b*, 15 feet above ground-level. Figs. 9 and 10 (plate viii.) show the general design of the headgear, and of the side supports, *c*, for carrying the pumps, on the east and west sides of the shaft. The pit-top doors, at both levels, *f* and *g*, were worked by an engine, with a steam cylinder 6 inches in diameter and 9 inches stroke, and an oil-cataract cylinder, thus making it impossible to open or shut the doors too quickly.

The sinking-scaffold was built of four main girders, an outside bulb-channel ring, and timber planking. It was supported by two locked-coil wire-ropes, 4 inches in circumference, worked from a steam-driven worm-geared capstan, 40 tons, capable of working either rope or both together at a speed of 60 feet per minute. The locked-coil winding-rope was 4 inches in circumference.

The shaft was lighted by two electric-light fittings, *h* and *i*, each having eight lamps of 32 candle-power, with twin-armoured cable, raised and lowered by a hand-winch with slip-ring electric connections.

Ventilation is produced by an electrically-driven enclosed type Waddle fan, *j*, 4 feet in diameter, capable of producing 20,000 cubic feet of air per minute, at a water-gauge of 4 inches, when used as a blowing fan. The air-pipes, *l*, are 24 inches in diameter.

Compressed air for the drills is produced by three electrically-driven Reavell two-stage air-compressers, each capable of giving 240 cubic feet of air per minute at a pressure of 80 pounds per square inch. The compressors will be afterwards used underground.

Sinking was continued on August 30th, 1906, in the Trias and in the Upper Marls of the Permian, with two Evans Cornish sinking pumps, 16 inches in diameter, hung on chains on the east side of the pit. The maximum feeder at one time was 850 gallons per minute.

The second crib-bed was made on the top of the upper limestone at a depth of 196 feet. Work was stopped in No. 2 pit, whilst No. 1 pit was being sunk through the quicksand. The second length of tubbing was then put in and finished.

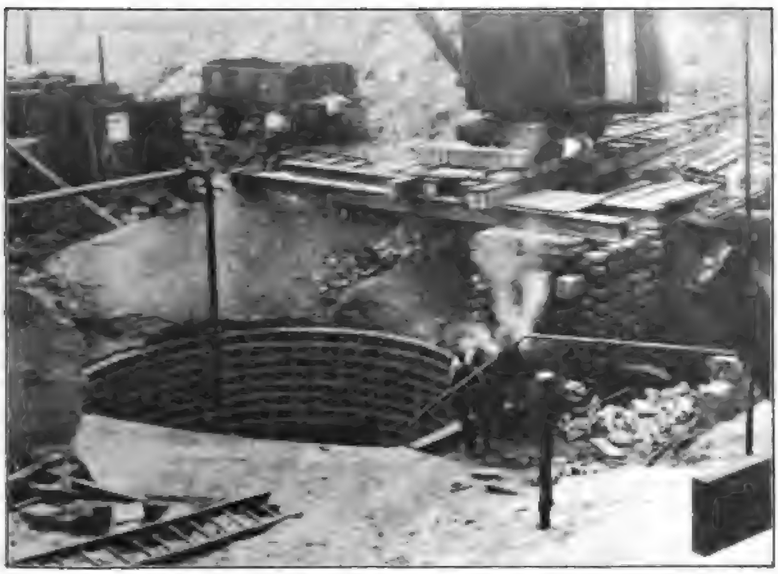

FIG. 13. —CONCRETE-BLOCK AT NO. 2 PIT, AFTER SINKING THROUGH QUICKSAND.

Holes were drilled in the limestone by the Walker drilling-frame and Hardy compressed-air machines. About 40 sump and side holes were drilled per round, taking from 3 to 6 hours of actual drilling. The same number of holes took 24 to 30 hours to drill by hand. The lower limestone required from 70 to 100 holes per round of shot. The shot-holes in the lower part of the lower limestone were drilled with Flottmann compressed-air drills. These machines strike about 1,500 blows per minute, and the drill is automatically given a slight twist after each blow. The drills have small centre-holes, running the whole length of the drill, and part

of the air exhausting at the point of the drill, keeps the hole clean. The total weight of the machine and the drill is 40 pounds. One man can drill a hole, 6½ feet long, including changing the drill, in 12 to 18 minutes. The total time occupied in drilling twenty-eight sump-holes, 6½ feet long, in hard limestone with ten machines, one man to each, is about 1½ hours. The side holes are drilled whilst the sump is being cleaned out.

The third crib-bed was made at 279 feet, and the fourth at 366 feet.

The shaft below this depth is lined with cement-brickwork, 9 inches thick, and the water met with (only about 40 gallons per minute) is collected in a water-garland, conveyed into a small lodge at a depth of 495 feet, and pumped to the surface by an electrically-driven Oddie-Barclay high-speed pump with mechanically-controlled suction-valves, running at 180 revolutions per minute.

The Evans pumps worked in a single lift for a depth of 330 feet, at which point considerable trouble was experienced with the buckets, which required changing frequently. The amount of slip varied from 35 to 80 per cent. From this point to the bottom of the Permian strata, the water was pumped in two lifts. Smaller pumps, hung on ropes from a steam-winch at the surface, pumped from the bottom to the lodge of the Evans pumps.

The top of the Coal-measures was reached in May, 1907, at a depth of 519 feet.

Sinking of No. 1 Pit.—In sinking through the quicksand at No. 1 pit, the same method was adopted. The cement-concrete block was made 6 feet thick and octagonal, instead of square, in shape; and 15 inches of space was left between the back of the tubbing and the side of the concrete, so as to leave room for clay to be rammed under the block as the ground fell away.

The floating-ring (fig. 8, plate viii.) was made much stronger, and consisted of two rings, E and F, of castings, with joints crossed, twelve to the circle, each 18 inches deep and 16 inches wide on the bed, planed on their ends, and bolted together with machine-bolts, 2 inches in diameter. The two rings, bolted to each other and stayed diagonally with channel-iron (fig. 3, plate viii.) weighed 26 tons.

The piles and other tackle were exactly the same as those used in No. 2 pit.

Sinking was commenced on September 22nd, 1906, and carried out in exactly the same manner as in No. 2 pit. The piles were, in this case, jacked right down to the top of the sandstone, which was reached at a depth of 98 feet on October 29th, 1906, or 5 weeks after commencing to sink.

The cement-concrete block did not move during the upper 40 feet of the sinking, and the total subsidence, after finishing, was only 3 feet. The whole block subsided practically equally, although it was cracked into four parts.

At a depth of 68 feet, the screws were removed at the surface, and the tubbing was supported by side-friction alone.

Throughout the sinking, the guide-ring kept perfectly sound and in a true circle. Forty-eight rings of tubbing were put on; and, after finishing, the shaft was not more than 2 inches out of plumb. None of the tubbing-segments were cracked.

The first wedging-crib was laid at a depth of 129 feet, and an inner lining, 20 feet in diameter, of plain tubbing was carried up to the surface.

Surface arrangements.—Both shafts are finished 20 feet in internal diameter, and fitted up for drawing 2,000 tons per day, at each pit. The general arrangement is shown in fig. 11 (plate viii.).

Winding-engines.—The winding-engines are the same for both shafts, each consisting of two cross-compound cylinders, the high-pressure being 35 inches in diameter and the low-pressure 58 inches in diameter and 6 feet stroke, fitted with Corliss valves, cut-off gear, steam reversing gear and Whitmore steam-brake and over-winding prevention gear. The two throttle-valves, 13½ inches and 24 inches in diameter respectively, placed on the top of each cylinder, are easily actuated together by a hand-lever. The drum is partly conical, having three dead coils and six working coils on a cone rising from 12 feet 8 inches to 13 feet 2 inches in diameter; four coils range from 13 feet 2 inches to 19 feet in diameter; and the remainder run on the parallel drum, 19 feet in diameter. Each engine-house is fitted with an overhead travelling crane.

The sinking-engine at No. 2 pit consisted fo two steam cylinders, 24 inches in diameter and 4 feet stroke, with a parallel drum, 8 feet in diameter, working with steam reduced to a pressure of 60 pounds per square inch through a reducing valve.

As soon as the Coal-measures were reached, the winding engine was used for sinking, and the temporary sinking engine was removed to No. 1 pit.

Power-house.—The power-house, fitted with an overhead travelling crane, contains one Davey-Paxman compound high-speed generating set of 100 kilowatts; one Scott-Mountain high-

FIG. 14.—BRICK-PILLARS AT NO. 1 PIT, AFTER SINKING THROUGH QUICKSAND.

speed set of 250 kilowatts; and two Rateau low-pressure turbine-generators, with barometric jet and spirojector condensers of 500 kilowatts. The four sets generate three-phase alternating current at a pressure of 550 volts.

The switchboard consists of four generating panels, and feeder and lighting panels. The current for lighting is transformed from 550 volts three-phase to 220 volts single-phase by Westinghouse static transformers with a Scott connection, placed behind the switchboard.

Condenser-water is pumped to the top of a Balcke tower, capable of cooling 92,000 gallons per hour.

Boilers.—Four Lancashire boilers, working at a pressure of 160 pounds per square inch, are each 30 feet long, 9½ feet in internal diameter at the back end, with flues 3 feet 9 inches in diameter. The shell consists of four plates, and the fronts are dished inwards and are supported from the shell with link stays. The boilers are fitted with Green economizers and Dixon down-take superheaters. An auxiliary steam-range, 7 inches in diameter, across the boiler-fronts, connected to each boiler, can be used in an emergency or for testing purposes.

The draught is produced by an electrically-driven single-inlet Sirocco induced draught fan, 50 inches in diameter, exhausting into an iron chimney, 80 feet high and 6 feet in diameter. This fan will produce sufficient draught for six boilers, at a water-gauge of 2½ inches.

Two Weir boiler-feed pumps are each capable of giving 8,000 gallons per hour, at a pressure of 160 pounds per square inch; and one of them is designed to force water into the boilers at any pressure between 40 and 160 pounds per square inch.

Water-supply.—Water is pumped from a well, 40 feet deep, into three tanks placed on pillars, 40 feet high, by a three-throw pump, belt-driven by a motor of 20 horsepower. This water, averaging 45 degrees of hardness, is softened for boiler use by means of a Bruun-Lowener water-softening plant capable of treating 8,000 gallons of cold water per hour. The hardness is reduced to about 4 degrees. The softened water runs into the reservoir, and thence to the feed-pump well.

Shops.—The temporary shops are divided into three compartments: (1) The fitters' and smiths' shops contain two single and one double smiths hearth, with a blowing fan; a heavy double-ended punch and shearing machine; a steam hammer; cold saw to cut joists, up to 18 by 6 inches: a screwing machine; a pillar-drilling machine; a radial drilling machine; a side planing machine; a lathe, etc. (2) The joiners' shop contains a wood-planing and thicknessing machine; a band-saw, etc. (3) The saw-mill contains a circular saw.

All the machines in the joiners' and fitters' shops are driven by a motor of 30 horsepower; the circular saw is also driven by a motor of 30 horsepower; and both motors are fixed so that, in case of breakdown, either motor can drive the machinery in either shop.

APPENDIX I.—Strata sunk through in No. 1 Pit, Bentley Colliery.

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
	Alluvium—				
1	Soil	0	9	0	9
2	Yellow and blue clay	7	3	8	0
3	Dark grey sand and drift-*coal*	6	7	14	7
4	Grey sand and gravel	6	6	21	1
5	Brown and grey sand	39	11	61	0
6	Grey sand, with pockets of sandy clay and a large quantity of drift-*coal*	17	0	78	0
7	Soft sandy clay ...	1	9	79	9
8	Very sandy red and blue clay, with *coal* and boulders ...	14	3	94	0
9	Red sand and gravel	4	0	98	0
	Permian and Trias—				
10	Soft red sandstone ...	32	6	130	6
11	Soft grey sandstone	2	6	133	0
12	Red marl, with layers of red and grey sandstone... ...	17	6	150	6
13	Red and grey sandstone, with marl-streaks	14	4	164	10
14	Red marl, with boulders	16	7	181	5
15	Broken limestone	1	2	182	7
16	Red marl	2	3	184	10
17	Grey limestone ...	20	3	205	1

APPENDIX II.—Strata sunk through in No. 2 Pit, Bentley Colliery.

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
	Alluvium—				
1	Soil	0	9	0	9
2	Yellow and blue clay	4	0	4	9
3	Dark grey sand and drift-*coal*	9	11	14	8
4	Waup clay	1	4	16	0
5	Grey sand and gravel	3	0	19	0
6	Brown and grey sand	38	6	57	6
7	Grey sand, with pockets of sandy clay and a large quantity of drift-*coal*	13	6	71	0
8	Soft sandy clay ...	1	0	72	0
9	Blue sandy clay ...	7	0	79	0
10	Very sandy red and blue clay, with *coal* and boulders ...	13	4	92	4
11	Stiff blue clay, containing glacial boulders	7	8	100	0
	Permian and Trias—				
12	Soft red sandstone...	27	0	127	0
13	Soft grey sandstone	1	6	128	6
14	Red marl, with layers of red and grey sandstone ...	20	0	148	6
15	Red and grey sandstone, with marl-streaks	9	2	157	8
16	Red marl, with boulders	22	10	180	6
17	Broken limestone ...	1	4	181	10
18	Red marl	3	0	184	10
19	Grey limestone ...	24	10	209	8
20	Grey limestone, with clay-partings ...	3	9	213	5
21	Dark-grey limestone, with gypsum partings	24	7	238	0
22	Dark-grey marl and gypsum	1	0	239	0
23	Red marl with gypsum-bands, up to 18 inches thick	28	0	267	0
24	Harder gypsum, with limestone	2	10	269	10
25	Limestone, with clay-partings	2	2	272	0
26	Grey limestone ...	204	0	476	0
27	Dark-grey limestone, with clay-partings	9	0	485	0
28	Dark-grey limestone, with pyrites ...	11	10	496	10
29	Very soft dark-brown clay	0	2	497	0
30	Dark limestone, with bands of hard marl	8	6	505	6
31	Strong grey marl ...	15	10	521	4
	Coal-measures—				
32	Soft-mottled blue and red shale	9	0	530	4
33	Light-blue bind ..	18	2	548	6
34	Grey sandstone ...	1	3	549	9
35	Strong blue bind ...	6	3	556	0
36	Stone bind with sandstone-streaks ...	15	0	571	0
37	Grey sandstone ...	49	3	620	3
38	COAL	0	5	620	8
39	Fire-clay	0	5	621	1
40	Grey bind	5	1	626	2
41	Sandstone-clunch ...	1	0	627	2

The PRESIDENT (Mr. C. E. Rhodes) asked the writers to give a comparative estimate of the difference in cost between the process adopted at Bentley colliery and the freezing process, if that method had been employed; to state whether there were insuperable difficulties against the adoption of that method; and what were the advantages of the system which had been carried out so successfully in the face of immense difficulties.

Mr. EMERSON BAINBRIDGE (London) suggested that the position and dimensions of the concrete-block should be indicated on the drawings attached to the paper.

Mr. G. A. LEWIS (Derby) asked how the space between the sinking tubbing, 23 feet in diameter, and the permanent tubbing, 20 feet in diameter, had been filled up.

Mr. A. L. STEAVENSON (Durham) wrote that the authors of this paper were to be congratulated on the accomplishment of a very difficult undertaking, the greatest care having been evidently taken to provide against the effect of pressure at the bottom, which had frequently, in similar cases, forced the casing out of plumb and ruined the work. At the same time, the account of the position of affairs in the No. 2 pit seemed to show that at a depth of 52 feet there was nothing to spare, and with several piles 6 feet into the sand, bent inwards at the bottom, they were not far from a failure. However, the sinking afforded experience which seemed to have enabled greater success to be attained with the next pit. A thickness of 100 feet of sand was a very unusual amount, and this narrative of difficulties overcome would no doubt be helpful to others in a similar plight.

Mr. H. M. CADELL (Bo'ness) asked what were the special advantages of the method of sinking adopted at Bentley colliery, and why piles were used to form the cutting-ring round the bottom of the tubbing. It seemed to him that a cheaper and more expeditious method would have been to have used strong steel or iron segments for the sinking cylinder, and, allowing the shaft to remain full of water, to excavate the sand by a grab-dredger, the inside of the cylinders being loaded with iron weights to make them sink as the sand was removed. There might be objections to this method, and he would like to know what, if any, they were. It was certainly remarkable that the depth to the rock

should have proved so much greater in the shaft than in the bore-hole. If the bore-hole was not exactly in the position of the shaft, there must either have been a precipice in the solid rock under the sand, or the borer must have been incompetent.

Mr. J. W. Fryar, replying to the discussion, said that, as recorded in the paper, the first attempt on the quicksand was a failure; no attempt had been made to hide that fact, and they had recorded the results for what they were worth. As compared with the cost of ordinary sinking (without any quicksand or other difficulties), the two pits at Bentley colliery cost about £12,000 more for sinking through the quicksand than in the case of an ordinary sinking. The cost of their failures was included, but he thought that it would be fairer to take the cost of sinking the second shaft only. All their difficulties had occurred while sinking the first shaft; they had the benefit of that experience in sinking the second shaft, which was put down in six weeks, and he did not think that the quicksand cost more than £3,000 more than an ordinary sinking in the absence of quicksand. The interval between the tubbings, 20 and 23 feet in diameter, had been filled with various materials, such as broken stones, bricks, and even quicksand.

The President (Mr. C. E. Rhodes) moved a vote of thanks to Messrs. J. W. Fryar and R. Clive for their valuable paper.

Mr. J. T. Stobbs seconded the resolution, which was cordially approved.

DISCUSSION OF DR. C. SANDBERG'S "NOTES ON THE STRUCTURAL GEOLOGY OF SOUTH AFRICA."*

Mr. John M. Liddell (Cobalt, Ontario, Canada) wrote that Dr. Sandberg's paper was highly interesting, and was well illustrated by the map attached thereto (plate xxi.). The subject was a very large one, and although the data given on the map formed, so far as the writer's experience extended, a true picture of the general structure of the country, the deductions as to the causes which had produced this structure must be highly speculative.

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 540.

The general lines of strike might be considered as evidence of lateral pressure from the south, from the east, and from the south-west, as shown in each case upon the map; but they also seemed worth consideration as evidence of fracture caused by the upheaval of the sub-continent as a whole, and by the gradual change of contour of the earth's crust. The key to all these curious geological occurrences might probably be found in the astronomical history of the earth itself, and especially in connection with its later changes of contour. It was a curious fact that most of the ore-bearing fissures, and many of the lines of strike, ran north-east and south-west, with cross-leads to north-west, and these phenomena seemed to be due to something more than local disturbance. They occurred throughout the Barberton district of the Transvaal, in parts of Canada, in Western Australia, and, he believed, very commonly throughout the world. They were thus roughly parallel (with cross-lines at right-angles) to the direction of the magnetic pole and possibly were influenced thereby. The magnetic direction being variable, it would appear that a large proportion of them might have occurred at specific periods in the earth's history. In Ontario, Canada, where the rock was in many places heavily loaded with metals, the rivers and lakes frequently followed the lines of fracture and showed them up on the map in strong relief. Much light would probably be thrown upon this subject by a detailed description of the development of the earth as a planet, from its first crude form to its present shape, and of the subdivision of its surface into continents. It seemed certain from the similarity of lines of strike and of fissure in the different continents that some powerful general influence had affected the globe as a whole. In this regard a view of the full-moon through a field-glass was of interest, as it showed strongly-marked lines upon the crust, which suggested an analogous occurrence on the earth. The occurrence of a given metal in one set of fissures, and of another metal in others, while some remained barren, suggested some external cause, in addition to the differences in the rock-materials in which they occurred. This conclusion was difficult to resist, in view of the fact that it was within the historical knowledge of humanity that the globe had, in recurring periods, been profoundly disturbed by astronomical influences, producing earthquakes, eruptions, and other crust-motions. With regard to the formation of pans, the most likely

theory was, he thought, that of underground streams, probably running in natural dykes, which alone would account for the depth and extent of many of the pans by providing a means of removing the waste-material. Some few, however, showed no water and no sign of waste or of a dyke, so that their origin remained very obscure. One especially, occurring east of Heidelburg, in the Transvaal, did not seem to fit any theory.

Mr. H. T. Foster read the following paper on "Roof-weights in Mines":—

ROOF-WEIGHTS IN MINES.

BY H. T. FOSTER.

Introduction.—In underground mining, the nature of the roof determines to a large extent the method of working adopted; and as seams are worked under widely different roof-conditions, the support and control of the roof in mines opens up a wide field for careful observation. The views given in this paper have been deduced from observations in longwall workings, and deal more particularly with the effect of roof-weights underground, that is, with the movement of the roof, from its first disturbance at the working-face to its final settling in the goaf, without attempting to deal fully with more complex questions, such as the subsidence of the overlying strata and its effect at the surface.

Of the many conditions requisite for success in longwall working, that of obtaining a uniform settling of the roof behind the working-face is one of the most important. In ordinary cases, the face should advance uniformly, whether it be straight or stepped. Gate-packs and waste-packs should be regularly built; and all timber should be withdrawn from the goaf, so as to let the roof bend and break in the waste. When the desired result is attained, the bending roof becomes a lever which assists materially in the work of coal-getting. As the working-face advances, the roof settles on the packs, reducing the height of the roads, with other phenomena, until all the roof-strata, from the seam up to the surface, have subsided to their maximum amount.

The intensity of the weight caused by the movement of the overlying strata depends upon several fixed conditions, such as the depth of the workings from the surface, the sections and conditions of the seam and of the overlying strata. It also depends upon conditions set up during working, such as the direction of the face, the rate of advance, and the degree of thoroughness with which the packing and stowing, replacing the solid coal in the goaf, can be carried out. With an insufficiently

stowed goaf, the weights are more severe than with a well-stowed one, and, in offering more evidence for a paper on roof-weights, more useful.

Roof-weights may be divided into three classes, namely: (*a*) First weight, limited to the working-face; (*b*) second weight, the goaf-weight, following the working-face; and (*c*) third weight, the general subsidence of the strata.

First Weight.—As the coal is extracted, the roof in the working-face requires artificial support, which is provided by means of props, bars and chocks. To some extent, these allow the roof to settle bodily towards the goaf, by compression of the supports, by crushing them into the roof or floor, or by breaking them. In the goaf, behind the timbering, the roof is able to settle more readily on the compressible packs which are built for that purpose.

The thickness of the strata taking part in the first movement, depends upon their strength. For instance, a thick rock-roof will hang back into the goaf for a considerable distance with practically no movement, and it may possibly render the seam unworkable by the longwall method; while a shale- or a bind-roof will bend and break in successive stages for a height of several feet, generally up to a harder rock. In all cases, it is the weight of the bending strata that props set in the working-places may be required to support, and this roof is under the direct control of the miner. The weight due to the bending of the roof at the face is the ordinary working-result, and constitutes the first weight in longwall working: the overlying strata remaining undisturbed during this stage.

In some instances, however, the roof may be unable to settle uniformly in the goaf, either by props or wooden packs being left behind, slants or oblique roads crossing the goaf, or by the roof weighting and locking itself (fig. 1, plate ix.). The locking of the roof is probably more common in cases where the roads are dinted and the roof left unbroken than where the roads are ripped. When locking occurs, the area of the roof, bridging the space between the packs, increases as the working-face advances, until its weight becomes excessive; and then it shears itself along the line of least resistance, which is generally the coal-face, and settles bodily. With a strong coal, there will be

only one or two breaks in the roof over the solid (fig. 2, plate ix.); but, with a tender coal, there will be several breaks extending a considerable distance over the solid (fig. 3, plate ix.). The result of the weight, so far as coal-getting is concerned, is that the roof-lever is destroyed; and the coal is set hard until sufficient coal has been worked to establish another roof-lever.

By their inclinations, weight-breaks give an indication of the direction of the force which is aiding coal-getting under normal conditions. They are almost invariably over the solid coal, whatever be the direction of the coal-face; but they have different inclinations, because the conditions of roof-weighting vary. The average inclination, A, is about 50 degrees from the horizontal, over the solid (fig. 1, plate ix.), but when the roof is locking itself, subsequent breaks become more nearly vertical, B, as the resistance to lateral movement towards the goaf increases (fig. 1, plate ix.).

It is also found that weight-breaks in dip-workings are more nearly vertical than those in rise-workings: that is, there is less lateral displacement for a given vertical displacement of roof in dip- than in rise-workings. The observed angles, from the horizontal, over solid coal, in a seam dipping 1 in 10 ($5\frac{1}{2}$ degrees) are:—Rise-workings, 45 degrees; level workings, 50 degrees; and dip-workings, 56 degrees. This difference in inclination is probably due to gravitation, and accounts to some extent for the different conditions of coal-getting in the three cases.

Under some conditions, with a heavy roof or tender coal, the face may be stepped: that is, each working-place is made to keep a previously determined distance in front of the next in order. The result of stepping the face is to make the roof in the goaf break in a diagonal line joining the loose ends, thus permitting only a portion of the weight to come on to the coal-face. If, however, one bank gets behind, the weight, advancing in a more or less straight line, will crush the exposed coal-corner, and the roof will break in the working-place and airway, A, where AB represents a working-place, and AC the cutting-side, which has become too long (fig. 4, plate ix.).

Although the first weight is mainly due to the weight of the subsiding roof, there are other influences at work which may modify its effect to some extent, and account for phenomena observed at a later stage of the roof-weight, when the face has

advanced a considerable distance from the part in question. One of these is the lateral compression of the strata. In the case of the seam being worked, this stress probably aids in coal-getting, the lateral movement of the roof being clearly shown by the props in the working-places riding towards the goaf, and it is one of the factors which determine the correct rate of advance of the face. When the coal is extracted, the stress in the roof-strata, aided by gravitation, expends itself in bagging the roof down between the packs, with the axis of the trough at right angles to the working-face, and usually parallel to the roads. In a similar way, the floor, aided in many cases by gas or water, lifts or creeps in the working-places and goaves. This lateral compression of the strata accounts for side-weight in the roads, to be described at a later stage, and also for the fact that the workings in an upper seam disturb the roads previously made in a lower seam.

The condition of the roof, goaf, and floor, after the first weight is shown in fig. 5 (plate ix.), which is an imaginary section taken parallel to the face across two gate-roads, one, E, being ripped and the other, F, dinted.

Second Weight.—As the coal-face advances, the roof bends or breaks in the goaf, due to the first weight, leaving columns of roof still supported by the packs (fig. 5, plate ix.), which, in turn, support the higher undisturbed strata. When a considerable area of the undisturbed strata has been undermined, it begins to subside, and the weight due to this subsidence is transmitted through these columns to the compressible packs, which are crushed to perhaps one-half of their original thickness; and, at the same time, the height of the roads is reduced.

The effect of the second weight is illustrated by fig. 6 (plate ix.), which is a section taken at right angles to the face. A is the line of the coal-face; B shows the roof still supported by the packs, but fallen or bagged down in the goaf between, due to the first weight; C is a line parallel to the face, where the goaf has been compressed by the second weight: this line is advancing at the same rate as the coal-face and at a uniform distance behind it.

The roof, between B and C, together with the subsiding upper strata, DD, which was undisturbed by the first weight, is bridging the space between the solid goaf, C, and B. Beyond

this line, towards the face, the upper strata, DD, are still undisturbed, although the roof may have subsided to some extent, due to the first weight. The area, enclosed between the lines B and C, is subject to second weight, and is subsiding on to compressible packs. The width, BC, depends on the strength of the strata involved in the second weight. It will naturally be greater with strong than with weak strata, and with a well-stowed than with an insufficiently stowed goaf. It will be seen that, as the second weight advances, the roof is subject to two curvatures, and where it follows closely on the first weight, due to insufficient packing, the roof in the roads is broken considerably in consequence of the double curvature (fig. 6, plate ix.).

When the coal is worked in stepped faces, the second weight, as in the case of the first weight, follows in the line shown in fig. 4 (plate ix.), thus cutting across the gates, DE, and FG, at an oblique angle. This is a disadvantage, as the sides crush off much more readily than in gates carried at right angles to the second weight.

Again, when faces are worked at right angles to one another (fig. 7, plate ix.), there is very little first weight to aid coal-getting in the fast corner; but, in the goaf, the second weight is destructive. The respective second-weight breaks, *d*, *e* and *f*, follow their faces, *a*, *b* and *c*, in a parallel line towards the fast corner, where they curve round and meet (fig. 7, plate ix.). The roads in the area of the curved breaks should, if possible, be set out to cross them at right angles, as AB, CD, and EF: because roads, with breaks crossing them at oblique angles, seldom stand well.

The effect of the second weight is mainly seen in the crushed packs and reduced height of the roads, necessitating their re-ripping or re-dinting. During the period of second weight, the roof should be allowed to settle on the packs as uniformly as possible. In many cases, wooden packs, put in the gate-sides, only tend to break the roof; and the old wood, so used, would be better employed in helping to bind the pack together, over a larger area. Middle props in the roads should also be avoided, especially with a hard floor, as they cut the roof, and ultimately get broken.

Where the roof has bagged down in the goaf (fig. 5, plate ix.), the second weight, in compressing the strata, tends to straighten

it. This pushes the roof into the gate, where it has lateral freedom, giving side weight (fig. 8, plate ix.). In the same way, the floor is pushed out into dinting-gates, or causes creep in the roads (fig. 9, plate ix.).

When the coal-face is abandoned, the second weight advances towards the face until it practically reaches it. The span, between the solid coal and the solid goaf, is reduced, until the higher roof can support the weight without further strain, and the strata are finally inclined by the amount of difference between the thickness of the seam and the crushed packs. As the second weight approaches the coal-face, the roof-strata, which have been elongated by the double curvature, are broken, and the breaks, AB, thus formed dip in the direction of the coal-face, showing that the weight is riding over from the goaf towards the coal-face (fig. 10, plate ix.). This may also occur in opening-out a new district, or where the goaf is insufficiently packed, thus allowing the second weight to follow the first weight too closely.

It will be seen that the conditions during the period of second weight are the reverse of those for first weight. In the second weight, the advancing line of settled goaf forms the fulcrum of the roof-lever, and the power is applied by the weight of the higher strata subsiding towards the retreating coal-face. The condition of the roads and goaf is shown in fig. 11, which is a section at C, drawn parallel to the face, A (fig. 6, plate ix.).

Thus the rate of advance of the face is determined by the first weight, and the direction and length of the gate-roads, cross-gates, and slants, are determined by the second weight: the weights in both cases being confined to the neighbourhood of the working-face.

Third Weight.—With the further advance of the coal-face, an increasing area of roof-strata is put upon the packs, which are crushed by the second weight to, approximately, one-half of their original height. This subsidence must, obviously, weaken the support of an increasing area of the overlying strata not previously disturbed; and, when the limit is reached, true subsidence begins. This is called, in this paper, the third weight; and its influence is felt in the seam, and through the overlying strata to the surface. The subsidence provides enormous pressure, and its effect is seen in the roads, in the further

and final crushing of the packs, in many cases down to one quarter of their original height, and in intensified side weights. The subsiding strata, or third weight, must also travel in the direction of the workings, spanning the space between the finally settled goaf, and the roof which is as yet undisturbed by the second weight. Thus the third weight follows the second weight, and in the majority of cases probably does so uniformly, without actual break in the strata, or cavity between the beds.

As to the direction of the pressure caused by subsidence, it is observed that in level roads, the bars often swing over towards the dip; and, where the road is ripped to a smooth parting, the rise-side of the road crushes over towards the dip, and the striæ on this parting are invariably in the direction of the dip of the seam, showing that there must have been movement between the beds in this direction during subsidence. This is also indicated in roads driven in the direction of the dip: the bars invariably ride over in that direction, and for this reason are set a little out of the perpendicular towards the rise.

The subsidence also induces planes of fracture in the roof-strata, which run in the direction of the level line of the seam. The inclination of these planes of fracture varies with the dip of the seam: in a seam dipping 1 in 10 (5½ degrees), the average inclination in a wide goaf-area is 68 degrees from the horizontal; thus, AB is an average angle for fracture-planes in Coal-measure strata (fig. 12, plate ix.).

As the subsiding strata are bounded on all sides by solid strata, and each bed is homogeneous, the pressure, CB, inducing these planes of fracture may be taken to be approximately at 45 degrees to them, or at 67 degrees from the horizontal, and in the direction of the dip of the seam (fig. 12, plate ix.). In some cases, especially where wooden packs have been built in the sides of the roads, the plane of fracture, BD, is practically at right angles to AB, or at 45 degrees to the pressure, CB (fig. 12, plate ix.).

At the rise side of a shaft-pillar in the same seam, the planes of fracture, AB, are roughly at an inclination of 58 degrees (fig. 13, plate ix.), and the ultimate weight-break, CB, which may be taken to represent the direction of the pressure, makes an angle of 45 degrees with these planes, or 77 degrees with the horizontal away from the solid coal.

The writer has come to the conclusion, from these observations, that in an inclined seam the direction of the general subsidence of the strata is towards the dip of the seam.

Effects of Subsidence.—To determine the probable effects of subsidence on the strata, two general cases may be taken: (1) workings in a level seam; and (2) workings in an inclined seam.

In the first case, when the level seam has been worked over a sufficient area, the first and second weights, following the working-face, cause subsidence of the roof, as previously explained, leaving the overlying strata bridging the space between A and B (fig. 14, plate ix.), these being the points nearest the face at which the second weight can act, with a moving face. At A and B, the roof-strata are as yet undisturbed; but, at C and D, they have subsided, probably one-half the thickness of the seam, so that the bed, from A to C, and from B to D, presents an inclined surface, while the subsided strata, from C to D, have a level surface, which is gradually extending. The writer does not suggest, however, that a cavity, ABCD, is left, except under exceptional circumstances; but that, in all cases, the disturbed roof over the goaf is capable of being compressed by the third weight to that amount.

The strata over CD are subsiding uniformly, but between AC and BD they are subsiding on inclined surfaces, forming a trough (fig. 14, plate ix.): each succeeding bed, towards the surface, being less and less inclined, and extending further over the solid coal (fig. 15, plate ix.). It must be remembered that the curves are very slight, and that the movement is slow and irresistible. As the beds are subsiding in ascending order, it follows that each bed must slide between the adjacent beds, the movement being towards the goaf-area in every case, due to the horizontal component of the pressure producing the subsidence. This pressure must diminish in intensity in the higher strata, due to decreased thickness of cover, until the surface is reached, when the pressure becomes zero at the line of initial subsidence, which advances at the average rate of advance of the coal-face. Thus, in the earlier stages of subsidence, the beds are subject to slight bending and horizontal movement, but subside evenly as the line of initial subsidence, or draw, advances.

In the second case, that of inclined strata, the writer's view is that over wide goaf-areas, the draw due to subsidence is towards the dip of the seam that is being worked, whatever be the direction of the coal-face. Taking as an example a rectangular pillar left for the support of the surface, and set out parallel to the direction of the dip and strike of the seam, the subsidence and draw over the sides of the pillar in the line of dip will be similar in extent to those of a level seam. They will probably be more destructive, however, as each bed must also move in the direction of the dip, as shown in fig. 16 (plate ix.), where AB is the side of the pillar; CD, at right angles to AB, are lines of strike before subsidence; the lines, C, D, their position after subsidence; and EF the line of final draw.

Lastly, the amount of subsidence and draw over the rise and dip-sides of the pillar will depend upon the direction and intensity of the inclined pressure, acting in the direction of the dip of the seam. On the dip-side, this force is assisting that due to subsidence in a level seam, and the amount of surface-draw should, for this reason, be greater. On the rise-side, however, the force is retarding that due to subsidence towards the goaf, and the amount of surface-draw should be less than in the case of a level seam.

From this reasoning, the writer has come to the conclusion that in leaving pillars in an inclined seam for surface-support, more coal should be left to the dip than to the rise of the area which has to be supported.

The writer has communicated this paper with the hope that it will be of general interest, and by creating discussion help towards the better understanding of a difficult subject.

Mr. W. E. Lishman (Durham) wrote that the question of the influence of depth upon rock-pressure was of special importance, in view of the fact that depth must necessarily play an increasing part in future mining operations. It was somewhat surprising that, while the matter of temperature in regard to depth had been the object of adequate investigation, that of pressure had been, comparatively speaking, neglected. Temperature-gradients, and the laws which govern them, were now fairly well established for practical depths; but no such authoritative in-

formation was to hand in regard to underground pressure and the way in which it operated. The result was that a certain amount of misconception prevailed on the subject, and it was too often assumed that the overlying strata exerted an excessive pressure upon the underlying seams, and that the support required increased approximately in proportion to the depth. It was therefore disappointing to find that Mr. Foster had not dealt with this aspect of the matter. There could be little doubt that the pressure, and therefore the roof-weight, on the whole increased with the depth; but that it increased at all materially within the possible (and comparatively small) depth-limit of mining operations was in most cases highly improbable. What was a much more important factor than mere depth was the nature of the overlying and underlying strata, and especially of those immediately above the seam. If these were good, they were to a large extent self-supporting; and it would be the exception, rather than the rule, that the sheer weight of any considerable thickness of strata should be brought to bear upon any excavation below.

The division into "first, second, and third weights" did not strike him (Mr. Lishman) as a very suitable one, nor were the conclusions drawn at all convincing. It would be an advantage to know whether the angles of fracture recorded were from direct observation, or were assumed. Such a plane of fracture as that represented by the line BD in fig. 12 (plate ix.) would appear contrary both to theory and to practice; while it was by no means clear how those shown in fig. 3 (plate ix.) as projecting over and beyond the coal-face were arrived at, especially if (as was apparently the case) they referred to advancing longwall. Mr. Halbaum had admirably stated the case for the cantilever action of the roof.* One could have wished that Mr. Foster had developed that method of inquiry; for, whatever difference of opinion there might be on points of detail, it afforded at least a useful basis for further investigation.

Briefly, what occurred in advancing longwall was something of this kind: the roof, at first, arched itself, between the coal-face in front and whatever support there might be behind. The fracture forming the arching might start from the coal-head or

* "The Great Planes of Strain in the Absolute Roof of Mines," by Mr. H. W. G. Halbaum, *Trans. Inst. M. E.*, 1905, vol. xxx., page 175.

from some distance behind it, or possibly (though rarely) beyond it. The precise angle and the height to which the fracture extended would depend upon the condition of the strata, etc., and upon the rate of advance. The fracture would take an appreciable time to travel upwards: if the face stood any length of time, the stress at this particular point would have time to project itself through an ascending series of strata; if, on the other hand, the face moved rapidly, the maximum stress was carried forward at the same time; and its effect was therefore distributed, instead of being concentrated for any appreciable time in one particular line. The result was a bending instead of a fracturing of the upper strata, and a steady but general subsidence instead of an intermittent and piecemeal one. The roof-action thus appeared to approximate to the condition of a loaded beam, supported at both ends. The natural arching would extend up to the neutral point for the time being. Above this, the absolute roof would be subject to compressive strains, and would develop oblique lines of weakness projecting away from the goaf-area and over the solid area, thus tending to produce draw at the surface. It was the loosened material (the fallen stone under the natural arching and confined to a short distance above the seam) that required artificial support. It was the cantilever action of the solid roof remaining below the neutral line that produced weight on the coal, and assisted the working of it.

The case of inclined strata required further investigation. Mr. Foster would hardly expect to carry the members with him when he advocated that more coal should be left to the dip than to the rise of the shaft. If it were correct that the line of fracture lay between the vertical and the perpendicular to the beds, the fracture then approached the shaft on the rise-side and receded from it on the dip-side, necessitating therefore more support on the rise-side. It was, however, possible in heavily-pitching strata that the fracture, on meeting with a hard panel, would be deflected from its regular course, and tend to follow underneath this bed to the rise, as affording the line of least resistance.

While unable to agree with parts of Mr. Foster's paper, he must congratulate him upon having brought forward a subject which required further elucidation.

Dr. James S. Dixon (Glasgow) wrote that Mr. Foster gave a very intelligent description of the weighting that followed the

extraction of coal by longwall or by working back pillars. In the latter case, in a level seam about 6 feet thick, by careful levelling on the surface prior to and after the working, it was found that the draw or angle of subsidence of the strata was about 76 degrees from the horizontal plane. This, of course, largely depended on the nature of the strata: if hard, the line of fracture was nearer the perpendicular than if soft. Where the line of fracture in the strata met a soft alluvial surface, it then ran away at a flat inclination, and affected the surface at a much greater distance than usual. In one case, where the seam dipped at an angle of nearly 45 degrees, it was found that the break took place at right angles to the seam, so as to cause damage to the surface at a distance from the point of fracture equal to the depth; whereas, in the case already referred to, this was only about a fourth of the depth. The subject of weighting, as affecting the coal-face and the roads, was one of very great importance, both as regarded the extraction of the coal and the subsequent expense in maintaining the roads in the waste, and was one that should be carefully studied in every seam. In cases where a thick hard stratum of rock existed, 50 or 60 feet above a coal-seam, this did not break until a considerable area of coal was worked, thus delaying the final crush. Till this stratum broke down, the weight thrown on the surrounding coal and the roads was so greatly intensified as in some cases to make it almost impossible to keep the workings open. When a surface-break occurred, this was relieved, and a regular steady subsidence ensued.

Mr. H. F. Bulman (Burnopfield) wrote that accurate observations were much wanted in connection with the important questions of roof control and surface subsidence, and Mr. H. T. Foster was to be congratulated on having added to the record. His observations in a seam dipping 1 in 10 were that the inclinations from the horizontal over the solid coal of the roof-breaks in longwall work were (figs. 17 and 18):—rise workings, 45 degrees; level workings, 50 degrees; and dip workings, 56 degrees; in a wide goaf-area, the average inclination of the planes of fracture was 68 degrees from the horizontal plane; and, at the rise-side of a shaft-pillar, the inclination was roughly 58 degrees from the horizontal plane, over the solid coal. But it was questionable

how far these observations supported Mr. Foster's conclusions that "the pressure inducing these planes of fracture may be taken to be approximately at 45 degrees to them"* and that "in an inclined seam the direction of the general subsidence of the strata is towards the dip of the seam†" and that "in leaving pillars in an inclined seam for surface-support, more coal should be left to the dip than to the rise of the area to be supported."‡

Of the forces producing subsidence, that of gravitation might be taken roughly to act in a vertical direction, but there was also a lateral movement towards the goaf, which would vary according to the extent of the open space to be filled. As Mr. Foster stated, there was a movement "towards the goaf-area in every case, due to the horizontal component of the pressure pro-

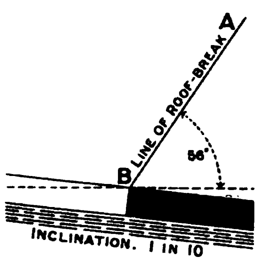

FIG. 17.—SHEWING OBSERVED LINE OF ROOF-BREAK IN A DIP-LONGWALL FACE.

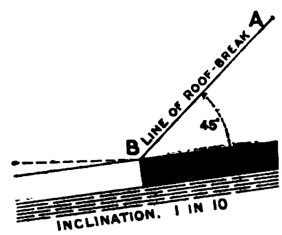

FIG. 18.—SHEWING OBSERVED LINE OF ROOF-BREAK IN A RISE-LONGWALL FACE.

ducing the subsidence."§ In the case of a longwall face, proceeding towards the dip, this lateral movement towards the goaf behind would tend to counterbalance the vertical movement due to gravitation, and it was difficult to see how the resultant of the two forces, one acting vertically and the other horizontally away from the solid coal, could be in the direction CB indicated by Mr. Foster in figs. 12 and 13 (plate ix.). Again, the line of fracture in a dip longwall-face, according to Mr. Foster's observations, was 6 degrees nearer to the vertical, or away from the solid coal than in a level-face, and 11 degrees nearer to the vertical than in a rise-face (figs. 17 and 18): as Mr. Foster stated "weight-breaks in dip-workings are more nearly vertical than those in

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 411.
† *Ibid.*, page 412. ‡ *Ibid.*, page 413.
§ *Ibid.*, page 412.

rise-workings."* Surely, the more acute line of roof-break over the solid coal (fig. 18) showed that the pressure extended further over that coal. Mr. Foster's observations seemed therefore to show that in a seam dipping 1 in 10 the roof-pressure extended further over a rise-face than over a dip-face. This agreed with the opinion hitherto generally accepted, that for surface-support in an inclined seam more coal should be left to the rise than to the dip of the surface to be supported.

The classification of the roof-pressure into first weight, second weight, and third weight was, perhaps, a little confusing, if one forgot that they only existed separately during the preliminary stages of working. Whenever a longwall-face had advanced far enough to allow the roof to come down on the goaf behind, the first and second weights were merged into one. Similarly, when the movement had spread to the upper strata, its effect was added to the total. It was misleading to suppose that there were three distinct weights acting separately and independently of each other.

Mr. J. P. KIRKUP (Burnhope) wrote that he presumed that Mr. Foster's paper was the outcome of experience, but thought that it could not be accepted as a complete summary of the subject. Some years ago, he (Mr. Kirkup) had an opportunity of seeing certain flexible sandstones, which in 1 foot of length could be bent several inches without fracture; and he believed that this flexibility in a somewhat less degree pertained to many of the rock-beds of the Coal-measures, and consequently affected roof-weights in mines. The subdivision of roof-weights by Mr. Foster could only apply to the early development of goaf-areas: if the strata immediately overlying the coal-beds were of a friable character, if they were strong and flexible (as they very often were), a considerable area could be exhausted without sign of fracture, and only symptoms of what Mr. Foster termed "second weight" would be evident. The effect of first weight was confined to any friable bed immediately overlying the coal, and that, in the writer's experience, often of very moderate thickness. In the case of a strong roof, no such first weight occurred, but a steadily progressive increase of pressure until the working-faces came under the full pressure exerted by the strata in movement, reaching from some distance

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 407.

over the coal-face to a position in the goaf, where they had come to rest. This distance might vary from about 180 feet in thin to upwards of 300 feet in thick seams. He (Mr. Kirkup) inclined to the opinion that the pressures exerted upon the coal-face at D did not represent what would result from the full weight of the superincumbent strata, but only that part which might be represented by a triangle, ABC (fig. 19). The sectional area, ACD, of pressures acts on the face of the coal-seam and on the adjoining goaf-area, while the sectional area, BCD, of strata, beneath the goaf-area, tends to heave by the action of the face-pressure, AB. The object of the miner should be to prevent the occurrence of any roof-fracture (which would tend to modify this), and by careful attention to

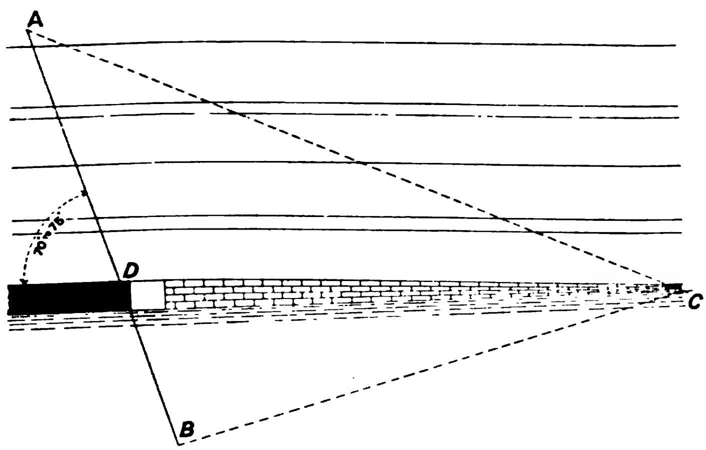

FIG. 19.—DIAGRAM SHOWING DIRECTIONS OF PRESSURES.

packing the goaf to gradually allow the pressures of the roof and floor to meet, at the same time keeping the working-face steadily progressing.

He (Mr. Kirkup) was extensively working two seams with the following section:—Depth from the surface, 600 feet; strong rock-roof, 20 feet; coal-seam, 1 foot 8 inches; band, from 3 to 12 feet; and coal-seam, 3 feet. Large areas of the lower 3 feet seam had been worked by the pillar-and-stall system, and the band proved to be a very bad roof, where it was about 3 feet thick; it improved where it was thicker. Subsequent to the exhaustion of the lower seam, the upper thin seam was opened out by the longwall system, and it was found to be very slightly broken: only sufficient to slightly modify its original hardness. The rock-

roof was practically without a fracture, and gateways were carried a length of 250 feet without the use of props: timber only being used as a precaution in the working-faces. The flexibility of this rock-roof allowed it to come to rest, after the working of both seams, without a violent fracture.

The lateral pressure transmitted through the flexible beds underlying the coal-seam produced different effects in varying underlying beds: in soft under-clays of a plastic character the effect in the roadways was much the same as that observed in a plastic brick-machine; in strong under-beds the floor moved similarly to the roof, in its efforts to assume a stable equilibrium by coming together: this caused the sides of a bottom-ripping to tilt and break upwards, and of a top-ripping to tilt and break downwards. This lateral movement of the beds underlying a goafed area had been observed to extend to a depth of 50 feet below, when the overlying strata had been 450 feet thick; with covers 600 feet thick, no movement was observed at a depth of 100 feet below a goafed area. The evidence from other workings at great depths would be interesting to the members.

Mr. Edward Watson (Akmolinsk, Siberia) wrote that Mr. Foster had very clearly pointed out many of the conditions requisite to the successful working of longwall, and the effects of the successive roof-weights. One very important point which he did not particularly mention was that of systematic timbering. The maximum distances between props and that between face and gob-rows, and also the distance to which the coal might be worked beyond the face-timbers, would have to be decided for each seam, or even each district of a seam, but, once fixed, the regular setting of timber must be enforced, and not left to the judgment of the workmen. The systematic setting and drawing of timber was, the writer believed, the great secret of longwall working. Mr. Foster had particularly mentioned his objection to leaving wooden packs, by which he (Mr. Watson) understood him to mean chocks. It would be interesting to know whether Mr. Foster had had actual experience of building wooden chocks in roadsides, and, if so, with what results.

At the present time, the writer was introducing the longwall method of working in Siberia. If any accident were to occur, the system would be condemned and forbidden. The seam, which was

an ideal one for the method, was as follows:—Coal, 5½ to 6 feet, covered by 1 foot 10 inches of soft shale, where the holing was done; above this was coal, 2 feet in thickness, which formed the roof in face, and first "rip" in the roads; above this again, there were 3½ inches of shale and 1 foot 4 inches of coal, which formed the second "rip," followed by 7 feet of shale, with bands of coal; and above these was 100 feet of strong post. The miners were quite unaccustomed to building packs, so wooden chocks measuring 4 feet by 4 were placed along the roadside, with 4 feet of building in between. So far, this system had proved most satisfactory, and the men were beginning to see the advantages of it as against the old method of bord and pillar.

Mr. H. T. Foster (Bentley), replying to the discussion, wrote that with reference to Mr. Lishman's remark on the angles of fracture given in the paper, the inclinations given, in every instance, were the average of the measured inclinations of a number of similar breaks, also that fig. 3 (plate ix.) was a cross-section, to scale, of an advancing longwall face in a tender seam, where the roof had sheared itself and lowered, due to heavy first weight. The amount of the displacement of the roof, and the position of each break, were measured in an advance heading.

Mr. H. F. Bulman's observations were confusing, owing, he (Mr. Foster) suggested, to his departure from the classification advocated in the paper. Mr. Bulman remarked that "it was misleading to suppose that there were three distinct weights acting separately and independently of each other."* The writer, in his classification of roof-weights, did not state that the three weights acted independently, but attempted to show that the movement of the roof-strata might be divided into three distinct stages, acting, in a fully developed mine, at the same time but over different areas. For instance, the roof adjoining a moving longwall face was subject to first weight; but, as the face advanced, the same area came under the influence of the second weight, and, finally, of the third weight, as explained in his paper. The writer agreed with Mr. Bulman in that "weight-breaks in dip-workings are more nearly vertical than those in rise-workings."† Mr. Bulman further remarked: "Mr. Foster's

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 418.

† *Ibid.*, pages 407 and 418.

observations, therefore, seemed to show that in a seam dipping 1 in 10, the roof-pressure extended further over a rise-face than over a dip-face. This agreed with the opinion hitherto generally accepted, that for surface-support in an inclined seam more coal should be left to the rise than to the dip of the surface to be supported."* The writer did not claim that the first weight-breaks necessarily influenced the amount of surface-draw. He would point out, however, that the inclination of the break in rise-workings, 45 degrees to the horizontal, would, if produced, give a longer horizontal measurement on the surface than the inclination of the break for dip-workings, 56 degrees to the horizontal. This was the reverse of the conclusion arrived at by Mr. Bulman, as a rise-face became the dip-side of a pillar, and a dip-face became the rise-side of a pillar, left for surface-support.

With reference to Mr. Bulman's observation on the resultant of two forces,† the writer would remark that figs. 12 and 13 (plate ix.) refer to the third weight over a goaf-area, the planes of fracture given being induced a considerable time after the working of the coal from that area, while the weight-breaks given were the result of the first weight at the working-face.

After quoting the inclinations of first weight breaks, and those of the planes of fracture due to the third weight, Mr. Bulman remarked: "But it was questionable how far these observations supported Mr. Foster's conclusions, that 'the pressure inducing these planes of fracture may be taken to be approximately at 45 degrees to them,' and that 'in an inclined seam the direction of the general subsidence of the strata is towards the dip of the seam.'"‡ The writer arrived at the assumption for the direction of the pressure producing the third weight in the goaf by the following reasoning:—When viewed over small areas, the roof-strata may be taken to be composed of brittle rocks, that is, when an excessive stress is applied they break off short, with little or no strain. He had found, in the wide goaf-areas, planes of fracture induced by the third weight, the majority having an inclination AB, but occasionally planes of fracture at right angles to AB, with an inclination DB (fig. 12, plate ix.). The planes of fracture extended in the direction

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 417.

† *Ibid.*, page 417. ‡ *Ibid.*, page 416.

of the strike of the seam, and did not depend upon the direction of the working-faces. In a testing-machine, compression specimens of homogeneous brittle substances usually fail by shearing along planes more or less at right-angles to one another, or at 45 degrees to the direction of the pressure applied. The fractures so obtained were also supported by theoretical reasoning. From observations in the mine, and the result of experiment, the writer submitted that the direction of the pressure might be that given by CB (fig. 12, plate ix.), but, at the same time, he did not suggest that the planes of fracture indicated the inclination of the line of surface-draw.

The writer agreed with Mr. Lishman that a common basis for the investigation of roof-weights is advisable, and he had attempted in his paper to state a general case with that end in view. He considered, however, that the question of the subsidence of the strata due to underground workings was too complex to be compared to the action of simple beams, as suggested by Mr. Lishman.

A general case might be taken, to explain further the writer's view of the movements of the upper strata—that of two longwall faces working in opposite directions, and separated by a goaf-area. It would be seen from fig. 15 (plate ix.) that the distance AC between the undisturbed beds and the finally subsided beds was practically constant, as the subsided strata followed the working-face at a uniform distance. Each bed was subject to two curvatures; and a cross-section, taken parallel to the face at A, would occupy in turn every position in the span from A to C. The roof-strata consisted of a number of separate beds or layers of varying sections and strengths. Each bed extended in all directions, and was free to move laterally between the adjacent beds. The undisturbed strata were under lateral compressive stress, and the beds offered more resistance to compressive than to tensile stresses. The beds were subsiding in ascending order.

Let the members consider a separate bed at A (fig. 15, plate ix.) on its first movement during subsidence. As the bed was uniform, its neutral plane passed through its centre; above the neutral plane the bed was in tension, and below this plane it was in compression, due to the bending produced. It might be stated with regard to beam-sections, that "the neutral axis invariably passes through the centre of gravity of the beam," and

that "the position of the neutral axis has nothing whatever to do with the relative strengths of the material in tension and compression."*

As the stress in any layer varied directly as the distance of that layer from the neutral plane, the tensile stress on the upper surface of the bed in question was equal in intensity to the compressive stress on its lower surface. When the stress was excessive, the bed would fail in tension in the upper layers. Usually, the compressive stress was practically unable to produce strain on the lower layers, and the tensile stress would produce the strain required for the curvature by lateral extension of the upper layers. The movement was towards the goaf, and it extended to some point further over the solid than point A (fig. 15, plate ix.). This became the point at which the compressive stress on the lower layer of the next bed, or series of beds, in ascending order, acted, while the tensile strain on the upper layers extended further over the solid and caused movement towards the goaf. This movement was probably aided by the natural stress in the strata.

Given beds of rock and shale, under similar conditions of thickness and stress, the rock, being able to resist tension better than shale, would be strained to a lesser extent in the upper layers. Consequently, the line of draw would be more nearly vertical in rock and hard strata than in shale and weak strata, as pointed out by Dr. Dixon in his remarks.† Again, the stresses must diminish in intensity in the higher strata, due to decreased cover, and for this reason the writer suggested that the line of initial draw might assume a more nearly vertical direction as the surface is approached. At a later stage of the subsidence over the goaf, the beds were deflected in the direction opposite to that due to the first movement over the solid coal. This reversed the conditions: in each bed the layers above the neutral plane were in compression, and those below the neutral plane were in tension. The strain produced counteracted that previously induced by the movement in advance of the coal-face, and the strata subsided evenly, probably retaining the natural stress due to the lateral compression of the strata.

* *Mechanics applied to Engineering*, by Prof. John Goodman, second edition, 1902, page 297.

† *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 416.

The writer, by the above reasoning, had attempted to account for the line of initial draw extending over the solid coal, and to prove that in an inclined seam the direction of the general subsidence of the strata in wide goaf-areas was towards the dip of the seam; and also that the movement of the roof strata overlying the solid coal was towards the goaf. On the dip-side of a pillar both forces were acting towards the dip of the seam, and should produce more surface-draw than the forces on the rise-side, which were acting in opposite directions. This led the writer to conclude that "in leaving pillars in an inclined seam for surface-support, more coal should be left to the dip than to the rise of the area to be supported." *

The PRESIDENT (Mr. C. E. Rhodes) moved a vote of thanks to Mr. Foster for his interesting paper.

Mr. M. WALTON BROWN seconded the resolution, which was cordially approved.

Mr. H. ST. JOHN DURNFORD read the following paper on a "Deep Boring at Barlow, near Selby":—

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 413.

DEEP BORING AT BARLOW, NEAR SELBY.

By H. St. JOHN DURNFORD, M.Inst.C.E.

Introduction.—The question of the extension of the Yorkshire and Midland coal-field to the east must always be a matter of very great interest throughout the country, but especially to those whose lot lies chiefly in the Yorkshire coal-field; and the writer therefore ventures to hope that the following notes on a deep boring which has recently been put down on the Earl of Londesborough's estate, near Selby, may be of interest to the members.

This estate, covering an area of over 10,000 acres, extends for a distance, roughly speaking, of 8 miles east and west by 2 miles north and south, and adjoins the old market town of Selby. The extension of the Coal-measures under this estate was a question as to which there was little doubt; but the particular depth at which they would be found was a matter largely of speculation, and in order to prove this, as well as in the hope of finding a workable coal-seam, a boring was undertaken. There were practically no data to enable his lordship's advisers to settle the best position of the bore-hole from a mining point of view; and it was, therefore, thought best to look at the matter chiefly from a geographical standpoint, and to place the bore-hole in the most convenient situation for a colliery to secure access to the shipping ports of the district. This being the case, it was considered that the most suitable position was that shown on fig. 1 (plate x.), whereby easy access could be obtained to the river Ouse, as well as to the main line of the North-eastern railway.

Before going into the actual details of the boring that was carried out, it may be fitting to remind the members of the stratigraphy of the neighbourhood. The boundary of the exposed Coal-measures, to the east of Leeds, runs from Parlington Park, a little north of Micklefield, where the Coal-measures out-

crop, in a line between Garforth and Micklefield, to Pontefract, to the east of which they are overlain by Magnesian Limestone. The latter is exposed as a belt, about 5 miles wide, running north-west and south-east, and the eastern boundary passes through Church Fenton, Thorpe, and a little east of Knottingley. The Permian is in turn overlain by the Trias, and the bore-hole at Barlow was started in the Bunter Beds of this series. It may be mentioned that Selby derives its water-supply from the Bunter Sandstone, a deep well having been put down, within recent years, at Brayton Barf, a little to the south of Hambleton.

The nearest working collieries to the Barlow bore-hole are Micklefield (about 12½ miles distant in a north-westerly direction), and Fryston collieries (about 11 miles south-west), where the Beeston bed is worked at depths of 750 feet and 1,620 feet respectively. The Coal-measures at these two places are dipping south-eastward, and it was to be expected that, at Barlow, the seams of the Lower Coal-measures would be proved at a very considerable depth from the surface.

New Calyx Drill.—The contract for the boring was let in March, 1904; operations were commenced about the end of July, in the same year, and were completed at the beginning of August, 1906, when a total depth of 2,371 feet from the surface had been attained. Considerable difficulty was experienced in obtaining an adequate water-supply, and delays were caused at one time and another on this account. The diameter of the hole, at the commencement, was 18 inches, and it was diminished from time to time on the insertion of lining tubes: the last 300 feet of the hole being 6 inches in diameter, from which cores, about 4½ inches in diameter, were obtained. The size of the hole was well maintained until the Coal-measures were reached, when it became necessary to line the hole, at more frequent intervals, with a consequent accelerated diminution of the diameter. Three times during the boring operations the hole was found to have deviated very seriously from the vertical, and, in one instance, as much as 80 feet had to be re-bored.

The new Calyx system of boring* is doubtless familiar to the members, but a short description of the plant and methods

* *Trans. Inst. M. E.*, 1898, vol. xv., page 363.

may not be out of place. The drill is, of course, of the rotary type, and in general principle is similar to the more familiar diamond drill, both employing the same method of water-flushing. The Calyx cutter, cylindrical in shape, is made of specially toughened tool-steel, the metal being about ½ inch thick, and has long teeth, with an alternately inward and outward set of about ⅛ inch after the manner of a joiner's saw. The speed of the cutter should not exceed about 10 revolutions per minute. The Calyx cutter is only used in the softer rocks; and when hard ground has to be bored through, it is replaced by a shot-bit, consisting of a cylindrical steel tube having triangular notches cut at the bottom, with a base of about 1¼ inches and 2 inches in vertical height. These notches allow the shot to gather on both sides of the bit, and also provide for the free circulation of the water used to flush the hole. The chilled shot used, No. 6 size, is washed downward through the hollow drill-rods. A quicker rotary motion is permissible when the shot-bit is being used than when using the Calyx cutter, and a speed of from 10 to 20 revolutions per minute is found to be most efficient.

The general arrangement of the boring plant is shown in figs. 2 and 3 (plate x.). The pine derrick, consisting of four main legs held together by ties and braces, was 50 feet high. The motive power was supplied by a horizontal engine with two cylinders. The wire-rope supporting the boring rods was coiled round a drum, 2½ feet in diameter, driven by a chain-belt, whence it passed over the top of the double crown-pulley fixed at the head of the derrick; and, forming a loop carrying the movable pulley attached to the rods, passed back over the crown-pulley and thence to the piston-rod of a hydraulic cylinder on the ground, to which it was firmly attached.

The hydraulic cylinder forms one of the most interesting features of the Calyx drilling plant. It consists simply of a cast-iron cylinder, with a piston-rod and a leather bucket inside, and it is, to all intents and purposes, a hydraulic weighing-machine. The writer believes that it is only within recent years that it has been used in connection with boring operations, and it is certainly a great deal superior to the old counter-balance-weight system—when it was largely a matter of guess-work on the part of the man in charge as to what pressure really existed on the cutter. By means of a gauge connected by a high-pres-

sure hose to the water in the cylinder, the foreman-driller can, at any time, ascertain the pressure on the tools, as the ratio between the pressure recorded and the actual pressure must always be practically constant. He can also by opening an exhaust-valve at the water-end of the cylinder, regulate the rate at which the rods travel downward to as near as 1 inch per hour. Perhaps the most useful feature of the hydraulic cylinder is that by its means the foreman can obtain a fair idea of the nature of the stratum in which he is boring. Suppose, for instance, the bottom of the hole was in sandstone, superimposed on a coal-seam, and that on lowering the boring tools into the hole, whose weight is, say, 8,000 pounds, a pressure of, say, 2,000 pounds is indicated by the gauge. On reaching the coal, a sudden decrease in the resistance offered to the tool would occur, and, consequently, a much greater pressure would be indicated by the gauge: in fact, practically the whole weight of the rods and cutter would be borne by the rope. Needless to say, these indications are of the utmost value to the man in charge of the boring.

The rotation of the rods is acquired by means of an arm clamped securely to the boring-rod, nearest to the ground-level; and this arm is at each end brought into contact with a strong upright steel pin, two of which are set in sockets diametrically opposite in a heavy cast-iron disc. This disc has, on the under side, a circular toothed-rack, geared into a vertical bevelled wheel, which latter is connected to the engine by two chain-belts working on toothed pulleys. This arrangement allows the rods to be lowered freely, until the aforementioned arm is at the bottom of the upright pins, when it is unclamped, and re-fixed higher up the rod.

The boring-rods are hollow, having external and internal diameters of 3 inches and 2½ inches respectively. Each rod is 15 feet long, and the rods are screwed one into the other, being disconnected in lengths of 45 feet. The bottom rod is secured to the core-barrel by means of a reducing plug, which also carries the cylindrical chip-cup, 6 feet in length, through which the bottom drill-rod passes. When boring is in progress, a constant circulation is kept up, the water passing through the drill-rods to the bottom of the hole, and upward between the core-barrel and the sides of the hole, carrying with it the mud and smaller

pieces of rock which have not gone into the core-barrel. When the water reaches the top of the chip-cup, the space is less confined; and, consequently, the velocity of the water decreases, causing the débris, carried by the stream, to fall back into the annular space between the chip-cup and the bottom drill-rod. The water emerges at the top of the hole, and flows away in a trough or some other prepared channel, and may be either turned into a drain or into the reservoir, and re-used as may be desirable. If any sediment is brought out of the hole, instead of being deposited in the chip-cup, it can be seen in the return-trough, so that it would seem almost impossible, if proper care is exercised, for any stratum of coal or coaly matter to be bored through without its presence being detected.

To extract the cores, a quantity of grit is washed down the rods, and it is arrested at the cutter or shot-bit, both of which taper slightly inwards at the bottom, so that, when the rods are lifted, the particles of grit become tightly wedged between the core and the sides of the tool and core-barrel and hold the cores tight. As the rods are raised, the bottom core snaps off, and the core-barrel is brought to the surface. The core-barrel is then suspended in the derrick, the cutter or shot-bit is screwed off, and usually a little hard knocking on the sides of the barrel will suffice to release the cores.

Bore-hole.—The ground-level at the top of the hole is 16·1 feet above ordnance datum-level. Having passed through a thin superficial deposit of soil and mud, the hole entered the Red Sandstone of the Trias, presumably the Bunter beds. The strata passed through, down to 720 feet or so, were practically all ferruginous sandstones. Below 720 feet, a series of marls, about 40 feet thick, was passed through. Whether these marls belong to the Bunter or the Keuper division of the Trias seems to be a matter of some controversy. Some writers claim all the Trias of the West Riding of Yorkshire as Keuper, whilst other authorities sub-divide the beds into Keuper and Bunter. At a depth of 754 feet, the hole entered a bed of gypsum, followed by a bed of anhydrite, the two having a total thickness of about 23 feet. This bed of anhydrite is very persistent throughout the neighbourhood, and is doubtless identical with that proved in the borings at Snaith, Thorne, and Southcar; and probably the same bed is being worked at Hillam, where it is converted

into plaster-of-paris. Beneath the anhydrite came another series of marls, interbedded with thin bands of gypsum.

At a depth of 800 feet, the Magnesian Limestone of the Permian was entered. The uppermost 100 feet of this limestone did not present any unusual features. It was very hard, and in places jointy, but gave excellent cores, and was, on the whole, good ground for boring. At 900 feet, thin bands of shale and gypsum occurred, followed by a bed of red marl, 64 feet thick. Underneath the marl came a bed of rock-salt, 20 feet thick. This would appear to be only a local deposit, and the writer fears that the depth, about 990 feet, might be a serious bar to profitable working. Some difficulty was caused at a later stage by erosion of the lining-tubes at this point, but a double set of tubes was inserted, one inside the other, and no further trouble arose on this account up to the time that the hole was abandoned.

This rock-salt was also the cause of a good deal of trouble with the water-supply to the boiler connected with the boring-apparatus at the surface. This boiler was of the ordinary portable locomotive type, and obtained its water from a pond, into which the water from the bore-hole, after various coursings in the prepared channels at the top, was allowed to flow. The supply of water in the pond was at times found to be insufficient to flush the bore-hole properly and to supply the boiler. The flow of water from the bore-hole, which in passing through the salt-deposit had become highly impregnated with salt, caused serious trouble with the boiler-tubes, and in a few days these were practically ruined. It cannot be too strongly urged that, in a deep boring of this character, an ample supply of good clean water is desirable, to be obtained from a stream in preference to a pond or reservoir, which is likely to become contaminated with the return-water from the bore-hole.

The rest of the Permian strata, from 990 to 1,305 feet, consisted of Magnesian Limestone, with occasional layers of anhydrite and marl.

At a depth of 1,305 feet, the sudden transition from Permian to Carboniferous, lithologically in this case from limestone to grey shale, occurred, and it was easily observable. The uppermost 100 feet of the Coal-measures consisted of blue and grey shales, apparently barren of coal-seams. At 1,406 feet, the first

signs of coal were met with, two thin streaks of coal occurring in a bed of sandy shale, 15 feet thick. Nothing further of particular interest was met with, until at a depth of 1,500 feet, at the bottom of a bed of blue shale, a shaly band, not more than 1 foot thick, was passed through, containing marine fossils. A number of *Pterinopecten papyraceous* and one or two *Goniatites* impressions were obtained from the core. An attempt has been recently made by a few eminent geologists to determine the zones of the Coal-measures by the marine bands, and the particular band referred to correlated with a marine band found immediately below the Ackworth Rock, at a boring near Pontefract and elsewhere. Through the kindness of Mr. E. L. Hummel, of Leeds University, the writer is enabled to show the members specimens of *Pterinopecten papyraceous* and *Goniatites* obtained from a boring at Wentbridge, near Pontefract, alongside of specimens obtained from the Barlow bore-hole, the two sets of fossils being much alike. The marine band referred to overlies a bed of fire-clay, 1 foot thick.

From 1,500 to 1,610 feet, the strata consist of grey and blue shales of a somewhat sandy nature, with an occasional thin layer of sandstone. In a bed of dark-coloured shale, occurring at a depth of about 1,600 feet, nodular hæmatite was found. At 1,615 feet, a seam of coal, 1 foot 3 inches thick, was passed through. The coal appeared to be very soft and friable, and did not form a core. The seam was underlain by 4 feet of fire-clay. From 1,615 to 1,900 feet, typical Middle Coal-measure strata were met with: shales, mostly of a dark and carbonaceous character; stone-bind, etc. Beds of fire-clay were passed through at 1,760 and 1,776 feet, being 1 foot and 4 feet thick respectively. From 1,900 to 2,000 feet, the strata was very much broken. At 1,924 feet a coal-seam, 9 inches thick, was found: the roof being sandstone and the seat-earth fire-clay.

Very abundant fossil plants were met with in the stone-bind and shale occurring between 2,000 and 2,040 feet, the following ferns being in evidence:—*Sphenopteris, Neuropteris heterophylla, N. tenuifolia, Alethopteris decurrens*, and *A. lonchitica*. Besides these ferns, numerous Calamites and some Stigmaria and rootlets were found. The ferns were submitted to Prof. Robert Kidston, of Stirling, who had no hesitation in saying that they had been obtained from Middle Coal-measures:

probably high up in the series. Specimens of these fossils may be seen by the members. The cores obtained at 2,100 feet contained several specimens of *Anthracosia* and *Anthracomya*.

At a depth of 2,122 feet, a seam of coal, 3 feet thick, was passed through. A core was obtained, but the coal was very hard and apparently of inferior quality. The seat-earth was a bed of fire-clay, 8 feet thick. From this bed of coal to the bottom of the hole the cores were very much broken up. At 2,170 and 2,200 feet, there was distinct evidence of faulting, although whether on a large or on a small scale it is impossible to say. The cores obtained from these depths were of a very crushed and dirty nature, and very distinct slickensiding was observable. Near the latter depth, the bedding-planes showed an apparent dip of about 70 degrees. Streaks of coal occurred at 2,110 feet. From 2,200 feet to the bottom, the strata were, if anything, rather less disturbed, and consisted of sandstone and blue shale, but the high inclination of the measures appeared to be accentuated with the greater depth, although a slight diminution was observable in the last 10 feet or so.

When a depth of 2,371 feet had been attained, boring was discontinued on account of the proved deviation of the hole from the vertical, and the very high inclination of the measures. In fact, it became evident that the line of the hole was so near to being parallel with the bedding-planes that a great deal of boring had to be done to prove a comparatively very thin section of strata.

On two occasions, experiments were made in order to prove the deviation of the hole from the vertical, the following method being adopted: An ordinary clear-glass quart bottle was partly filled with liquid cement and placed in a cylindrical case, into which it fitted tightly so as to allow of no lateral movement. The case was of steel, and had a tightly-fitting lid to protect the bottle from the enormous water-pressure at the bottom of the hole. At each test, a case was used of practically the same diameter as the bore-hole at the particular point where the test was to be made. The first test was made when the hole was at a depth of 2,120 feet. The case was lowered into the hole by the boring-rods on a Saturday morning, and was allowed to remain at rest on the bottom until the following Monday, when it was pulled up and the bottle withdrawn. The line of

the cement set in the bottle used in the first test shows that the line of the hole at the depth of 2,120 feet was inclined to the vertical at an angle of about 15 degrees. Boring was continued in the hope of somewhat straightening the hole, and a further test was made at a depth of 2,300 feet. The bottle used in the second test shows that the deviation was slightly less than was the case at the higher point, the angle being about 12 degrees. It must be admitted that these tests were only of a very rough-and-ready character, and no attempt was made to ascertain the direction in which the deviation had taken place. In spite of careful inquiries, the writer was unable to obtain any reasonably economical apparatus guaranteed to give practical and satisfactory results as to the direction of dip in a bore-hole, although theoretical methods would seem to be numerous; and, as the value of such information did not warrant a costly outlay, no attempt was made to ascertain the direction of the deviation.

With reference to the question of the deviation of the bore-hole, it is interesting to note that at a depth of about 2,200 feet it was found necessary to insert a long length of casing, 6 inches in diameter. This was lowered down the hole in one length of about 180 feet, and passed easily down to the bottom. Some difficulty was found in releasing the casing from the rods, with which it was lowered, and this fact would tend to show that the deviation must have taken place very gradually, and the writer has therefore prepared a sketch (fig. 4, plate x.) showing what, in his opinion, really had taken place in this bore-hole. He is of opinion, however, that when it is at all feasible, careful tests should be made at regular intervals of, say, 150 feet in a new bore-hole, to ascertain both the amount and direction of any deviation that might have taken place, so that an accurate record of the exact line of the bore-hole could be obtained.

From a careful consideration of the apparent dip of the measures as shown in the cores, it was observed, throughout the Trias and the Permian, that the bedding-planes were at right angles to the line of the bore-hole, from which it is evident that the stratification as far down as the Coal-measures is horizontal. In Coal-measure strata, however, the apparent dip was very small at the top, but appeared to increase as the hole became deeper, as already mentioned, the bedding-planes near the bottom of the bore-hole being nearly parallel with the sides of the

cores. This might be accounted for to some extent by the reasonable assumption that the deviation of the bore-hole gradually increased in a line following the dip of the measures, although the writer has heard that this latter point has been disputed. The increase of the dip, however, was so very marked that this explanation, although possibly correct as far as it goes, is very inadequate; and, to account fully for the facts, one must assume some disturbance of the strata, either in the way of a series of faults, or, what seems more probable, a folding of the strata

Fig. 5.—General View of Plant.

combined with some faulting. It has been suggested that the Don faults, which appear in the neighbourhood of Denaby and Cadeby collieriës to be running in a north-easterly direction, may be continued across the coal-field in the same direction, which would result in a disturbance of the strata in the neighbourhood of Barlow. As, however, a distance of about 20 miles separates Denaby and Cadeby from Barlow, a very slight change in the direction of these faults would destroy this theory, although, of course, the state of affairs suggested is quite conceivable. The theory most consistent with the observed facts

is that the bore-hole passed through the Coal-measures on the limb of a monoclinal or an anticlinal fold, and fig. 4 (plate x.) suggests the probable nature of the stratigraphical conditions, as indicated by the apparent dip shown in the cores. The bore-hole proved some 1,060 feet of Middle Coal-measure strata, and as geologists tell us that no thickness of 500 feet of such strata is known to exist in England without containing a workable seam of coal, it is very probable that the bore-hole has gone down through the limb of a fold, where the seams have been either thinned or pinched out altogether; and, if another bore-hole were put down in the neighbourhood, some distance from the site of the present one, normal conditions might be found to exist, and the same thickness of strata that was proved at Barlow might be found to be rich in the coal-seams usually found in the upper portion of the Middle Coal-measures.

FIG. 6.—BORING DERRICK.

It has, in fact, been suggested by Mr. Elmsley Coke, of Nottingham, that the beds of fire-clay passed through are the seat-earths of coal-seams and that, had the bore-hole been more fortunately situated, the seams would have been found intact. It is, of course, possible that some very thin seams of coal may have been passed through without being detected; but, in the writer's opinion, the system adopted, although, of course, not infallible, rendered it a virtual

impossibility to bore through a seam, 6 inches or 1 foot thick, without any indication of its presence, that is, of course, if reasonable care were exercised by those in charge.

Conclusion.—In conclusion, the writer wishes to express his indebtedness to the many gentlemen who have taken so kindly an interest in the undertaking, more especially to Prof. P. F. Kendall, Mr. Walcot Gibson of the Geological Survey, Mr. Elmsley Coke of Nottingham, Prof. F. W. Hardwick of Sheffield, and Mr. E. L. Hummel of Leeds University, for their invaluable co-operation and the benefit of their wide experience.

APPENDIX.—SECTION OF STRATA IN A BORE-HOLE AT BARLOW, NEAR SELBY, IN THE PARISH OF BARLOW, COUNTY OF YORKSHIRE, DURING 1904-1906. LATITUDE 53° 45′ 20″ AND LONGITUDE 1° 2′; 16·1 FEET ABOVE ORDNANCE DATUM-LEVEL.

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
	Alluvium—				
1	Dark-brown clay	24	0	24	0
2	Brown clay: friable	14	0	38	0
3	Red sand... ...	1	0	39	0
4	Clay	15	0	54	0
5	Sand	18	0	72	0
6	Red sand... ...	22	0	94	0
	Trias—				
7	Red sandstone: broken... ...	56	0	150	0
8	Red sandstone ...	50	0	200	0
9	Red sandstone: friable	80	0	280	0
10	Mottled red marl	2	0	282	0
11	Red sandstone ...	8	0	290	0
12	Red sandstone: solid	197	0	487	0
13	Red sandstone ...	95	0	582	0
14	Red sandstone, mixed with marl	43	0	625	0
15	Grey sandstone ...	45	0	670	0
16	Red sandstone ...	2	0	672	0
17	Red marl... ...	1	0	673	0
18	Red sandstone ...	22	0	695	0
19	Red marl... ...	6	0	701	0
20	Red marl, with sandstone-layers	4	0	705	0
21	Red and mottled marl	10	0	715	0
22	Red marl... ...	4	0	719	0
23	Red marl and sandstone ...	1	0	720	0
24	Red marl... ...	34	0	754	0
25	Gypsum	2	0	756	0
26	Gypsum	1	0	757	0
27	Anhydrite ...	4	0	761	0
28	Anhydrite ...	13	0	774	0
29	Red marl: friable	0	6	774	6
30	Marl and gypsum-bands	5	0	779	6
31	Red marl: friable	16	6	796	0
32	Marl, with bands of gypsum ...	4	0	800	0
	Magnesian Limestone—				
33	Limestone, with bands of gypsum	16	0	816	0
34	Limestone ...	4	0	820	0
35	Limestone ...	35	6	855	6
36	Limestone: jointy	38	0	893	6
37	Limestone, with bands of shale and gypsum ...	10	0	903	6
38	Red marl, with layers of limestone	64	0	967	6
39	Rock-salt ...	20	0	987	6
40	Limestone ...	20	6	1,008	0
41	Blue marl ...	1	0	1,009	0
42	Anhydrite ...	5	6	1,014	6
43	Blue marl ...	1	0	1,015	6
44	Limestone ...	4	6	1,020	0
45	Red marl... ...	1	0	1,021	0
46	Limestone ...	25	6	1,046	6
47	Limestone, with veins of gypsum	45	0	1,091	6
48	Limestone ...	137	6	1,229	0
49	Limestone: honeycombed and jointy	35	0	1,264	0
50	Limestone ...	41	0	1,305	0
	Coal-measures—				
51	Grey shale ...	12	0	1,317	0
52	Blue shale ...	2	0	1,319	0

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
53	Blue shale	29	0	1,348	0
54	Grey shale	28	0	1,376	0
55	Dark - coloured shale	18	0	1,394	0
56	Blue shale	12	0	1,406	0
57	Sandstone and sandyshale, with *coal*-veins	15	0	1,421	0
58	Blue shale, with sandstone-layers	19	0	1,440	0
59	Blue shale	60	0	1,500	0
60	Fire-clay	1	0	1,501	0
61	Blue shale	18	0	1,519	0
62	Light - coloured sandy shale	7	0	1,526	0
63	Blue shale	45	0	1,571	0
64	Grey shale	6	0	1,577	0
65	Dark - coloured shale, with iron-stone-nodules	7	6	1,584	6
66	Sandy shale	4	6	1,589	0
67	Dark-blue shale	26	0	1,615	0
68	COAL	1	3	1,616	3
69	Fire-clay	4	0	1,620	3
70	Blue shale	29	9	1,650	0
71	Grey shale and sandstone-layers	32	0	1,682	0
72	Blue shale	9	0	1,691	0
73	Stone-bind	13	0	1,704	0
74	Dark-blue shale	27	0	1,731	0
75	Fire-clay	1	0	1,732	0
76	Sandstone	4	0	1,736	0
77	Stone-bind	8	0	1,744	0
78	Blue shale	24	0	1,768	0
79	Dark - coloured shale	4	0	1,772	0
80	Fire-clay	4	0	1,776	0
81	Stone-bind	5	0	1,781	0
82	Light - coloured shale	6	0	1,787	0
83	Dark - coloured shale	13	0	1,800	0
84	Light-grey sand-stone	14	0	1,814	0
85	Blue shale: very friable	5	0	1,819	0
86	Stone-bind	18	0	1,837	0
87	Blue shale	3	0	1,840	0
88	Stone-bind	2	0	1,842	0
89	Blue shale	41	0	1,883	0
90	Grey sandstone	41	0	1,924	0
91	COAL	0	9	1,924	9
92	Fire-clay	4	0	1,928	9
93	Shale: rotten	48	3	1,977	0
94	Blue shale	7	0	1,984	0
95	Stone-bind	74	0	2,058	0
96	Blue shale	61	0	2,119	0
97	COAL: inferior	3	0	2,122	0
98	Fire-clay	8	0	2,130	0
99	Light - coloured stone	40	0	2,170	0
100	Blue shale	8	0	2,178	0
101	Light - coloured stone	17	0	2,195	0
102	Blue shale, with *coal*-veins	22	0	2,217	0
103	Grey sandstone	63	0	2,280	0
104	Blue shale	91	0	2,371	0

The PRESIDENT (Mr. C. E. Rhodes) said that the question of the extent of the Coal-measures, existing at a workable depth and of a workable character, was of primary importance to the future of mining in the South and West Yorkshire coal-fields. It was unfortunate that the bore-hole at Barlow appeared to have been put down either in close proximity to some faults or to an anticlinal. It was difficult to conceive that the dip of the Coal-measures could vary as the hole became deeper; but it certainly appeared that the inclination of the measures altered after reaching Carboniferous measures. This variation tended to prove that at a certain depth the boring was possibly deflected alongside a fault, and the apparently high inclination of the measures might thus be accounted for. In the successful boring at Southcar, to a depth of 3,195 feet, the cores showed that the Coal-measures at Southcar were absolutely uniform, so far as one could form an

opinion, as to dip and inclination, from top to bottom. At Barlow, he could not help thinking that some dislocation of the measures had deflected the direction of the bore-hole. and rendered the conclusions unsatisfactory.

Mr. G. DUNSTON (Doncaster) said that the measures in the Southcar boring* appeared to be perfectly flat, from the top to a depth of 3,195 feet 3 inches. It would be of very great interest to the whole of the West Riding, from the point of view of the water-supply, if in new borings put through the New Red Sandstone they could know at what depth the Pebble-bed Series was found and its thickness, and if possible the samples of the water should be taken and analysed. As a member of the Sanitary Committee of the West Riding County Council, as well as a mining colleague, he would be glad to receive any information as to the quantity and quality of the water-supply from that portion of the New Red Sandstone.

Mr. W. WALKER (H.M. Inspector of Mines) said that the bed of rock-salt, 20 feet thick, if extended over a considerable area, could, he thought, be worked to profit at a depth of 967 feet. In the Middlesbrough district, it was worked at a depth of 1,300 or 1,400 feet; but was of much greater thickness. As regarded the dip of the strata at the bottom of the bore-hole, he agreed with the theory advanced by the President, that the boring-tool had come in contact with a fault and been deflected by it, and the cores made the beds appear as if they were practically vertical.

Mr. R. McLAREN (H.M. Inspector of Mines) said that a boring to a depth of about 4,535 feet had been put down in the eastern portion of Fifeshire; and the core at the bottom was less than $\frac{3}{4}$ inch in diameter. It had been proved that that bore had been deflected from the vertical. He suggested that the bore-hole at Barlow might have been deflected, not so much through meeting a fault as meeting hard strata.

Mr. J. H. MERIVALE (Broomhill) did not think from the evidence that the strata necessarily lay at a high angle as sug-

* "The Eastern Extent of the Midland Coal-field, and the Exploration at Southcar," by Mr. George Dunston, *Trans. Inst. M. E.*, 1896, vol. xii., page 515.

gested: the cores seemed to prove that the strata were horizontal, and the apparent dip arose from the deflection of the bore-hole.

Mr. JOHN T. STOBBS (Stoke-upon-Trent) remarked that in the section of the bore-hole, at the top, there were first red marls, next magnesian limestone of Permian type, underlain by red marls with rock-salt. The rock-salt of Middlesbrough and Cheshire was Triassic, and was superior in position to the Permian Magnesian Limestone. What was the reason for placing the rock-salt, in this case, in the Permian system? Magnesian limestone did occur in many formations, and if the fossils in this magnesian limestone or dolomite were of Permian type, then the underlying red marls would also be Permian. Possibly the underlying red marls might contain fossils, and if they were Triassic that would prove this magnesian limestone to be Triassic rather than Permian. It was an important point, in studying the geological structure of a coal-field, that the nomenclature of the beds should be accurately determined by reference to the fossils. The variation of dip of the strata shown was not common, but in a shaft, in North Staffordshire, the strata in the upper portion were almost horizontal, whilst lower down they were almost vertical, and, of course, the shaft was vertical throughout. If, as had been suggested, the bore-hole had been deflected by a fault, that would be revealed by the nature of the cores; and if the cores were sound throughout, the bore might be considered not to have been deflected by a fault. He did not think that a despondent view should be taken because cores were not obtained of the coal-seams. If the depth was over 1,500 feet, and the diameter of the hole was only 1½ or 2 inches, it was quite possible in drawing the rods that fragments of the core of coal, which was necessarily tender and fragile, might drop out.

The record of the bore-hole constituted, he thought, additional evidence of the value of palæontology to mining engineers. In striking Coal-measures, buried beneath upper beds, whether Triassic alone or Triassic and Permian, it was of the utmost importance that mining engineers should know what chance there was of getting payable coal-seams, and their opinion of the prospect was determined very largely by the position in the Coal-measures at which the first coal was struck. The author stated that some people were attempting to zone the Coal-measures by marine

bands; but this "zoning" was by fresh-water molluscs. It was a pity that the specific names of the molluscs mentioned in the paper had not been determined, for it made all the difference as to whether the *Anthracomya* was *Phillipsi* or *modiolaris*, as indicating an upper or lower zone in the Coal-measures.

It seemed to him that the direction of the anticline, whether north and south, or east and west, was important. An anticline running east and west pointed to the fact that it was a member of a series of earth-movements, which probably detached the Yorkshire and Durham coal-fields. The Durham Coal-measures rose southward and cropped out underneath the Magnesian Limestone, pointing to the existence of an anticline extending in an east-and-west direction to the south of that coal-field. The paper was one of the most important contributions in recent years to the solution of the problem of the extension of the Midland coal-fields.

Prof. G. R. Thompson (Leeds) asked whether there was any evidence of the direction of dip in the bore-hole. Two theories had been propounded—one that the dip was due to an anticline in the carboniferous rocks, the other that it was local and due to faulting. Presumably the anticline suggested would be that bounding the Yorkshire coal-field on its northern side, and having got to the south of the axis (Market Weighton axis), the beds should dip to the south on the first supposition; but, on the supposition of a fault, the dip might be in any direction. The cores showed evidence of sliding having taken place along the bedding-planes, due to a folding movement; this might, however, be due to the proximity of a fault or to earth-movement.

Mr. John Gerrard (H.M. Inspector of Mines) said that, in this country, engineers concentrated their attention on getting cores of the strata; but, in other countries, information was obtained as to the amount and direction of the dip of the strata, and he thought that attention should be devoted to these matters in this country. In Ireland, rock-salt was worked at a depth of 900 feet in three or four mines. The thickness, however, of the salt-bed was of more importance, as regarded its being workable, than its depth. He could not say whether a bed, 20 feet thick, would be profitable to work, because it was necessary to leave a considerable thickness of the salt under the marl for support. In Ireland

the beds were much thicker than 20 feet; and at Fleetwood, where the largest amount of rock-salt in this country was being worked, the deposit was about 700 feet deep, and two beds, 30 or 40 feet thick, were being worked. The absence of coal-seams in a thickness of 500 feet of strata, was not exceptional: at Bradford and Manchester, 1,200 feet of strata did not contain a workable seam. He did not attach much value to records of the thickness of coal-seams, because they were determined in a rough-and-ready way, and when details were sought it was often found that there was a good deal of guesswork about them.

Mr. C. Fox Strangways (London) wrote that the Barlow boring was of considerable interest, from the fact that the site was at no great distance from the northern boundary of the Yorkshire coal-field, and within the area where these measures had in all probability an easterly strike. Owing to the unfortunate deviation of the lower part of the bore-hole, much valuable information was lost; but, if the Coal-measures were much disturbed at this point, as appeared to be the case, this led to the supposition that a bore-hole sunk somewhere in this district, but away from the line of probable disturbance, would afford better evidence of the character of these underlying measures.

Dr. Wheelton Hind (Stoke-upon-Trent) wrote that there was little to discuss in Mr. Durnford's paper from a palæontological point of view. But he was not aware that any attempt had been made to zone the Coal-measures in Britain by their marine bands. What had been done was this: the Coal-measures were zoned by the species of *Anthracomya* and *Carbonicola*, and the marine bands were most useful accessory aids, when the relation of each to the zone-species of *Anthracomya* and *Carbonicola* was determined. It would be interesting and important to know if the species *Anthracomya Phillipsii*, the zone-index of the Black-band Series of the Upper Coal-measures, was found in the blue and grey slates which seemed to form the upper part of the Coal-measures in the boring.

Prof. Edward Hull (London) wrote that he had read with much interest the paper descriptive of the deep boring for coal at Barlow, near Selby, by Mr. St. John Durnford; and could not but share with all concerned in what must have been deep

disappointment at the final result of an experiment on so bold and expensive a scale. The site of the boring was well chosen for purposes of market and material, but was highly critical as regarded the margin of the Yorkshire coal-field in its eastern extension under the New Red Sandstone and Permian formations. On referring to his (Prof. Hull's) generalized map of the British coal-fields,* he found that the supposed concealed margin of the Yorkshire coal-field was drawn to pass close to the spot where the boring was made; or just a little south of this place, and on referring to the map of the Yorkshire coal-field† it would be seen that the line of the northern boundary was defined by a large upthrow fault, ranging from west to east about 2 miles north of Leeds and disappearing beneath the Magnesian Limestone. As the boring at Barlow seemed to be very much in the line of this fault in its eastward extension, he was inclined to believe that the disturbed and steep dip of the Coal-measures below a depth of 2,200 feet was to be accounted for by proximity to this fault, by which the Millstone Grit, or even older rocks, were brought up against the Coal-measures. He preferred this explanation to that adopted by Mr. Durnford, namely, that the high inclination of the strata was due to a "monoclinal or anticlinal fold," which in these northern districts was less frequent than faulting, in fact, quite exceptional. This boring should prove of great importance in determining the northern limit of the Yorkshire Coal-measures under the newer formations of the Permian and Trias. He feared that it must now be assumed, throughout the large area between the rivers Ouse and Tees, that Lower Carboniferous strata alone were to be found under the newer formations—either destitute of beds of coal—or only with occasional thin seams of the Millstone Grit series. The problem remaining to be solved was the extension of the Yorkshire Coal-measures eastward; they had been proved as far east as Southcar. As regarded the geological age of the marls "about 40 feet thick" below the Red Sandstone at a depth of 720 feet in the boring, there ought to be no question; they belonged to the Permian or Magnesian Limestone series, and the sandstone overlying them was the New Red Sandstone,

* "The Coal-fields of Great Britain," by Prof. Edward Hull, 1905, fifth edition.

† *Ibid.*, page 176.

or Bunter. The occurrence of rock-salt at a depth of 987 feet in the Magnesian Limestone series was remarkable and rare. The boring appeared to have commenced below the Saliferous Marls of the Keuper Series in which rock-salt might be expected, and it might have been supposed that rock-salt would be absent throughout the section. He concurred with the author in believing that such an unlooked-for mineral stratum would have presented a great, if not insuperable, obstacle when putting down shafts for the mine.

Mr. J. KENNETH GUTHRIE (Leeds) wrote that, as far back as 1879, in conjunction with Mr. C. Z. Bunning, he read a "Description of an Instrument for ascertaining the Inclination, from the Perpendicular, of Boreholes and the Direction of such Inclination,"* and it seemed rather surprising, notwithstanding it was well known that bore-holes did depart very considerably from the vertical, that holes costing a large amount of money and of the greatest importance should still be put down without adequate survey. In the instrument in question, 1 part of hydrofluoric acid to 4 parts of water were used in a flat-bottomed colourless ground glass vessel, and if the instrument were kept still for ½ hour, the level of the liquid would be marked in the shape of a ring upon the glass; then some of the liquid was taken out, so that its level in a horizontal position would mark itself below the lowest line of the first mark. In practice, the glass was placed in a water-tight case: with the exception of guttapercha ring-flanges, this case was made of brass, on account of the enclosed magnetic needle.

Having obtained the angle of deviation from the perpendicular at a measured depth, the direction of this deviation in a horizontal plane, that was, its magnetic bearing, was found as follows:—The glass containing the etching liquid was fitted into a ring, in rigid connection with a compass, and similarly divided into degrees. If this connection, of which the glass with the ring and the compass were parts, was inclined in any direction whereby the line of inclination was found by means of the liquid in the glass, the direction in a horizontal position of this line was read off the divisons on the ring in which the glass was set; if at the same time the compass was read, the difference of these readings would be the magnetic bearing of

* *Trans. N. E. Inst.*, 1879, vol. xxix., page 61.

the line of inclination. In carrying out this method in practice, it was necessary that the reading of the magnetic needle in the bore-hole should be recorded when the instrument was brought to the surface. This was accomplished by fastening the needle in the bore-hole, by means of a watch (forming part of the instrument), after sufficient time for settling had been allowed.

This instrument was successfully used in practice, and in trials made in wrought-iron tubes; in tube-lined holes the average of a number of measurements should be taken, but the results were not much affected if the instrument was placed in the middle of the tube-lining, and if the tubes were not possessed of longitudinal seams and joints.

The needle was hung so that up to an inclination of 18 degrees it was free to move in a horizontal direction.

Prof. F. W. Hardwick (Sheffield) wrote that Mr. Durnford's paper was one of great interest, not only on account of its important bearing on the extension of the West Yorkshire coalfield, but also on account of the clear description which was given of the system of boring practised. The deviation of bore-holes from the vertical appeared, unfortunately, to be a not uncommon occurrence. In borings undertaken for such a purpose as the one at Barlow, this deviation necessarily rendered the indications furnished by the bore-hole less important than they would be if the hole were vertical. In borings undertaken for subsequent sinking by the freezing processes, this deviation must introduce a great element of uncertainty. In a paper by M. Niederau,* on the sinking of the shafts at Harchie by the Pœtsch system, diagrams were given showing the deviation of the bore-holes put down around the sites of both the shafts. No hole appeared to be quite vertical, and the obliquity of some was considerable; no hole was deeper than 770 feet (235 metres). In this case the bore-holes were surveyed by an apparently simple method, which perhaps was not suitable to borings of great depth.

The description of the Macgeorge method of surveying bore-holes, given by Mr. Bennett H. Brough,† was well known, but the writer had been unable to obtain any information as to more

* *Annales des Mines de Belgique*, vol. xii., page 655.

† *Mine Surveying*, third edition, page 323.

recent applications of the method. Several other methods of ascertaining the deviation of bore-holes were also mentioned by Mr. Brough. The fact of the measures being steeply inclined, especially towards the bottom of the bore-hole, would, had the bore-hole been vertical, have rather negatived Mr. Durnford's statement that "The bore-hole proved some 1,060 feet of Middle Coal-measure strata."* The boring attained a depth of 1,060 feet below the lowest bed of the Permian, but the "thickness of Coal-measure strata" proved would depend on the angle of dip of the strata, that is, presuming that the word "thickness" meant the section of each bed at right-angles to the planes of bedding.

A correction was therefore necessary, in order to make the section given comparable with sections taken in borings and sinkings in which the strata were lying at a lower inclination. If the deviation of the bore-hole from the vertical were also in the direction of dip of the strata, this would still further magnify the apparent thickness of the individual beds passed through.

It was to be hoped that further investigations would be undertaken in the neighbourhood of the Barlow boring, as such were undoubtedly needed to throw light upon the somewhat perplexing problems mentioned in the paper.

Mr. H. St. John Durnford, replying to the discussion, said that no attempt was made to determine the direction of the dip of the strata. He had made enquiries, and could not find anybody competent to survey the bore-hole at a reasonable cost and guarantee reliable results, and consequently no attempt was made to survey the measures. It was not always desirable to divulge the prices of contractors; if he were a contractor himself he might give them a quotation, but as he was not he could not say much about the price. It was a mistake to say that he was not interested in the rock-salt: he could not say whether it was thick enough to work; but they might see a salt-mine there, before they finished. So far as he knew, there were no fossils in the magnesian-limestone measures, and nothing had been discovered of a nature to determine what was the age of that particular limestone.

Had the apparatus described by Mr. Guthrie been available, or been used recently in the neighbourhood, he would have been

* *Trans. Inst. M. E.*, 1907, vol. xxxiv., page 436.

very glad to have tried it; but, for the purpose of ascertaining the amount of deviation of the hole, he was inclined to think the cement test adopted gave results quite as satisfactory as those obtained with hydrofluoric acid. So far as the determination of the direction of the deviation by means of a magnetic needle was concerned, he had not heard of any very satisfactory practical results having been obtained with any of the various instruments advocated.

With regard to Prof. Hull's criticism, he (Mr. Durnford) knew that the site of the hole was in close proximity to the northern limit of the concealed coal-field, as shown in that gentleman's book on the *Coal-fields of Great Britain*. He was not aware, however, that the fault mentioned by Prof. Hull had been proved beyond the limits of the exposed coal-field, and the actual position of that fault as far east as Selby could only be a matter of conjecture. Prof. Kendall, in his report to the Royal Commission on Coal-supplies,* stated that—

"The northern boundary is formed by a persistent fold..... The Coal-measures along the whole length of the visible edge of the field (about twenty miles) rise against an anticline bringing up the Millstone Grit. This anticline can be followed to the eastward for a few miles under the discordant cover of Permian rocks, and then it and all other details of the structure are lost sight of beneath the featureless mantle of Drift and Alluvium which covers the Vale of York."

It would appear to be a little difficult to reconcile this with Prof. Hull's remarks, and he must confess the evidence of the cores seemed to his mind to give credence to Prof. Kendall's opinion. It might be that the hole had gone down on the southern limb of the fold referred to by the latter authority. The boring at Southcar referred to by Prof. Hull was, as could be seen from the plan, only a short distance eastward of the boring at Barlow, and this latter was as far to the south as the limits of Lord Londesborough's estate would permit. It was interesting to note that the northern boundary of the concealed coal-field, as suggested by Prof. Kendall on the plan accompanying his report, and as accepted by the Commission, was some four miles north of the site of the bore-hole. The coal-field was shown on this plan as extending some distance further to the north-east than shown on Prof. Hull's map, and the fact

* "Sub-report on the Concealed Portion of the Coal-field of Yorkshire, Derbyshire and Nottinghamshire," by Percy Fry Kendall, *Final Report of the Royal Commission on Coal-supplies*. [Cd.2361], 1905, part ix., page 19.

that at Barlow some 1,500 feet of Coal-measures were met with would rather go to prove the correctness of Prof. Kendall's conclusions. It might be mentioned, without placing any undue reliance on the statement, that the man in charge of the bore-hole always considered that the deviation had taken place in a South-easterly direction.

In answer to Dr. Wheelton Hind, he (Mr. Durnford) believed that the *Anthracosia* found were all of the species *acuta*, but he was not able to state the species of the *Anthracomya*. He did not think, however, that it was confined to any particular life-zone.

He thought that additional borings would have to be made in the district before this part of the coal-field could be exploited with success, or still less condemned as unlikely to give scope for profitable mining operations.

The President (Mr. C. E. Rhodes) proposed a vote of thanks to Mr. Durnford for his paper.

Mr. J. T. Stobbs seconded the resolution, which was cordially approved.

DISCUSSION OF MR. H. S. GAY'S PAPER ON "A SINGLE-ROOM SYSTEM OF MINING: AN ADAPTATION OF THE LONGWALL METHOD TO WORK IN THICK SEAMS."*

Mr. H. S. Gay (Logan, West Virginia, U.S.A.) wrote that the system had now been operated for almost three years, and since writing the paper he had gained additional knowledge on the subject. He had succeeded in obtaining a machine to lift the bench of coal, usually 3 to 4 inches thick, which was left by all chain-machines after a cut had been made. This work was called "scrapping the bottom," and was done by the poorest class of labour; it required from four to six men, depending on the nature of the coal, which varied at times. The machine used was called an "electric coal-puncher." It furnished its own compressed air to operate the drill. Two men with this machine could do the work of six men picking by hand.

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 558.

The gain effected had been offset somewhat by the distance between the sub-entries having been reduced from 120 to 100 feet, winning, however, the same proportion of coal. This alteration was almost necessitated in some places where the roof had numerous transverse-fissures and was not as stony as where the vein had first been worked.

Where the roof was good, portable posts were the cheaper to use; when the roof was poor, and the timber was an item to be considered, they could be used to advantage. But if they were spaced, say, 10 feet apart, and any of the roof was liable to fall when they were being removed, it would not be a safe operation, while it would be the case if they were, say, but 3 feet apart. In a country, therefore, where the roof was good and timber abundant, the system could be worked to decided advantage without the use of portable posts.

The system of single-room working had developed a principle in mining of which the writer had no previous knowledge. With a strong roof, when 75 per cent. of the coal were removed, if anything occurred the natural inference would be that it was a case of squeeze. In the present instance this was not the case. The pillars had proved stronger than the roof. The rooms were gradually closing, and every pillar so far as could be seen remained undisturbed. Had the proportion been made just half by driving the rooms 45 feet and the pillars 15 feet wide, he believed that they would in time have been crushed, even though there were no general squeeze. This danger could consequently be averted in certain cases by so proportioning the rooms and pillars that the crushing strength of the pillars was greater than the transverse strength of the overlying strata. He was not willing to admit that these pillars could not be recovered, or that such a modification could not be adopted by which as much coal, or more, might be won as by any other system now in vogue.

DISCUSSION OF MR. HERBERT F. BROADHURST'S PAPER ON "WATER-SUPPLIES BY MEANS OF ARTESIAN BORED TUBE-WELLS."*

Mr. Robert Wood (Morpeth) wrote that he had read Mr. Broadhurst's paper with great interest. The demand for the class of well mentioned was increasing year by year. Most of the available surface-supplies which were of any importance had been secured, and some of them (if not most of them) required a large expenditure of money in constructing filter-beds, bye-passes, etc., with a view to purifying the water and making it fit for domestic use. It would, in his opinion, in many cases have been much better and cheaper for the persons interested to have put down boreholes, and, where necessary, to have pumped their own supplies, which, as Mr. Broadhurst stated, could be done at much less cost than purchasing from water-companies.

Some time ago he (Mr. Wood) had put down a borehole at Newbiggin-by-the-Sea for the purpose of obtaining a supply of water for the manufacture of aërated waters. The hole was 2½ inches in diameter and the total depth 120 feet, of which the first 60 feet was in Boulder-clay. The clay had in it a number of boulders, rendering it very difficult to bore; strong flush-jointed steel tubes, 2½ inches in diameter, were put down through the clay into a grey shale, sealing off the surface-water. A 2-inch deep-well lift and force-pump was also put down inside the tubes, the working-barrel being 95 feet from the surface; this was worked by a small gas-engine. As a result, the amount of water obtained was 13 gallons per minute, or (working 12 hours per day) over 9,000 gallons of excellent water per day. The cost of boring and tubing the hole amounted to £33 7s. 6d., and the pump and gas-engine (purchased second-hand) cost about £65, making a total cost of about £100. Working the same for 300 days per annum at 9,000 gallons per day would produce 2,700,000 gallons of water annually, and the cost for gas at 1½d. per thousand gallons (which was an ample allowance) would amount to £16 17s. 6d. per annum. To purchase the amount of water just mentioned from a gentleman, who had a supply within two yards from the works, would have cost

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 473.

1s. 2d. per thousand gallons, or an annual expenditure of £157 10s. It would be seen from these figures that a saving of £140 12s. 6d. would be effected on the first year's working, or more than the total cost of borehole and machinery, thus bearing out Mr. Broadhurst's statements. In the figures above-mentioned, he (Mr. Wood) had made no allowance for attention to the machinery, as in the case referred to none was required, the engine being kept running for making the mineral waters.

He was at variance with Mr. Broadhurst when that gentleman stated that it was not now necessary to have sunk wells.* He agreed that in many cases it was not necessary to sink wells, that is, where the quantity obtained in an artesian bored tube-well was sufficient to meet the supply required. Where this was so, the last-mentioned well was preferable, being less expensive than a sunk well. There were, however, some difficulties to be taken into account in reference to artesian bored tube-wells, such as the tubes wearing out by corrosion, or by the action of certain acids in the water on the iron; and, further, there was the trouble of getting to the working parts of deep-well pumps when clack-seats, etc., required renewing. It was absolutely necessary in many cases to have sunk wells, especially where the supply in the borehole was not large enough to meet the daily requirements. A sunk well was then necessary, in order to get sufficient storage in which to collect the water at night to meet the demands made upon the spring during the day.

A case of this kind came within the writer's own experience at the recently erected sanatorium for consumptives at Barrasford-upon-Tyne, where a borehole was put down through clay, freestone, shale, limestone, and into whinstone, a total depth of 100 feet, 43 feet of which was in limestone. The yield of water when the whinstone was struck (which would have made it very expensive if it had been necessary to bore further) was 6 gallons per minute rising to the surface, not sufficient to supply the sanatorium and leave a reserve for cases of emergency, such as fire, etc., and it was therefore decided, after due consideration, to sink a well to a depth of 30 feet, and to make a large storage-drift capable of holding a fortnight's supply. The first 7 feet of clay was walled round with pick-dressed freestone, set in cement, and carried from the top of the stone-head to 2 feet above the

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 475.

surface; the walling was filled up behind with cement, thus preventing any contamination from the surface. The drift was excavated in the freestone, and, when completed and connected to the borehole, the yield of water was treble the quantity coming to the surface, due to the reduction of head. By this process, therefore, the supply of water was increased, besides forming a reservoir which would probably cost less in repairs, and would also keep the water much cooler than a reservoir made on the surface. Further, the latter kind of reservoir would have probably cost as much or more money than the well and drift together. The pump, which stood on the surface, was worked by a self-regulating wind-mill, duplicated by a small petrol-engine, furnishing the building with a supply of cool, pure water, naturally filtered.

In two other instances, namely, at Newbiggin-by-the-Sea and at Woodhorn, wells had to be deepened in order to obtain storage for the water. Standage was all that was required, and this had to be obtained below the water-level. It might be suggested that by further deepening the borehole a greater supply of water would have been obtained, which might have risen to a higher level, and so saved the cost of sinking. At the first-named place (Newbiggin), from the writer's own experience, there had been a large expenditure of money on boring experiments, with abortive results, and as it was very unlikely that the water would rise above sea-level, it was considered necessary to deepen the well below that point. At the last-named place (Woodhorn), a difficulty was experienced in deepening the borehole in the well on account of the existence of colliery-workings below. In both these cases excellent results were obtained.

The well of the future for efficiency and economy, generally speaking, was no doubt the artesian bored tube-well; but certainly it did not overcome all the difficulties of sunk wells.

Mr. Broadhurst had stated that, for tubing boreholes, flush-jointed tubes were useless.* He (Mr. Wood) thought that this must either be a clerical or a printer's error. He was, however, generally in agreement with Mr. Broadhurst in his remarks as to tubes; it was very important that strong steel tubes should be inserted for artesian tube-wells, as these, in addition to bearing the extra strain of screwing, driving, and lifting, would also

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 476.

wear longer, and were not so likely to depreciate through corrosion. It was certainly better to sink through the surface-clay than to put in faulty tubes. He had tried ordinary steam socket-jointed, swelled-jointed, and flush-jointed tubes. The last-named were certainly the most satisfactory, not requiring the same amount of driving as the others, and in cases where tubes had to be withdrawn, the process was accomplished more expeditiously. Furthermore, clay had a tendency to swell in the hole, which made it very troublesome to remove the swelled and socket-jointed tubes, which, in itself, was an important consideration.

Whenever it was anticipated that a large quantity of clay, gravel, or sand would be met with, it was advisable to begin the hole on such a scale as to admit of the introduction of larger tubes than it was intended to employ to finish with, especially where Boulder-clay was intersected with beds of sand and gravel.

It was often the case that the tubes could only be driven a certain distance on account of whinstone and limestone boulders partly projecting into the borehole, these being usually difficult to cut by means of the cutting-shoe on the end of the tubes. In cases of this kind it was best to reduce the size of the borehole, unless the hole was only down a short distance from the surface, when it would be advisable to restart a new borehole. The same trouble was experienced when coming into contact with beds of sand and gravel, which ran into the hole, and this could only be prevented by driving the tubes through the sand or gravel into the clay or stone below, and commencing the hole from that point at a reduced size.

One of the greatest difficulties met with in percussive boring was a loose whinstone boulder in the clay, and it was often found necessary, and was generally successful, in such cases to break the boulder up by a gelignite shot.

The ordinary method of boring by screwed-jointed iron or steel rods with chisels, etc., was satisfactory for boreholes put down to moderate depths; but the screwing and unscrewing of the rods was very slow: and, when boring to a considerable depth, the method was anything but economical, and therefore undesirable.

The second method of using poles instead of iron or steel rods was unsatisfactory, because a hole of very small diameter

could not be bored with them, and, further, the usual screwing and unscrewing of the rods had to be contended with, as before mentioned.

The third method of using rope instead of iron or wooden rods was more expeditious than the two last-mentioned methods. Less time was occupied in drawing the tool to the surface for changing and cleaning purposes, but in this method it was difficult to know what kinds of strata were being passed through.

The fourth method of using hollow rods or tubes for percussive boring, when water was pumped down the rods to wash away the débris while the work was in operation, was better than the others, as a considerable amount of time was saved, the cuttings being carried to the surface by the force of water. Here, again, the same trouble was experienced in withdrawing the tubes when a change of mineral was reached or a sharp tool required.

The fifth or "diamond" system of boring was better than the methods previously mentioned: by rotating the tubes or rods, on the end of which was a crown-bit set with diamonds, a channel was cut in the stone; and this allowed a core to pass up the core-tube, which could, if desired, be broken off by a core-catcher and taken out. Not only was the work done expeditiously by this method, but it also gave a correct section of the strata passed through. When boring for water by this system, a great difficulty might be experienced in procuring the water necessary to clear the débris from the borehole, and also for supplying the boiler for steam purposes. It was a very expensive system, and could only be economically employed for holes that had to be bored to a considerable depth. Here, again, the method was exceedingly slow, on account of having to screw and unscrew the rods when changing the ends.

The sixth method of boring with chilled shot should prove cheaper than the diamond system, and ought to be suitable for hard stones; but in soft clay, etc., it would be very troublesome, and there would be the usual waste of time in changing the tubes.

For some months past the writer had been experimenting, with a view to the invention of a system of percussive boring by steel rope, which would bore a core, or otherwise, as desired, and at the same time remove the débris as the work advanced, by using the water in the bore-hole repeatedly, thereby saving all pumping.

The object in view was to invent a boring apparatus which would do the work effectively, expeditiously, and economically, and would in effect save the greater part of the time lost in changing the rods. This object had so far been accomplished. He had tested a freestone quarry with this tool, working the same by hand. Good cores had been obtained, showing a section of the freestone passed through. At present, he was having a machine constructed for giving a percussive motion to the tool by means of cams. A winding drum was also attached to the machine for withdrawing the tool from the borehole. This machine was worked by a petrol-engine. One reason for using this class of engine instead of a steam-driven engine was that it was lighter for transit, could be quickly started, required very little water (only a few gallons for cooling the cylinder), and it could be run at a small cost. He was adopting these engines for pumping-plants for wells, quarries, etc., and was obtaining excellent results.

The question of pumping from wells, as Mr. Broadhurst had stated, required serious consideration. In many cases it was desirable to make a test with temporary plant, previous to installing permanent pumping machinery. Where water was required for baths, it was important that steam should be used, if possible; it would certainly be a great saving if the exhaust-steam could be utilized for heating the water. It would also seem desirable to have steam in large laundries.

For water-works, public and private companies, and also for large private residences, the cheapest and most economical powers were suction-gas, gas-, oil-, and petrol-engines. At present he had a small petrol-engine pumping water from a shaft 102 feet deep. The engine was of 2 horsepower, running at 400 revolutions per minute. This speed was reduced by means of gearing to 40 strokes per minute on the pump; the length of stroke was 2 feet, and the diameter of the bucket 4½ inches. As a result, he was obtaining an efficiency of about 75 per cent. on the pumping-plant, the cost being 1d. per horsepower per hour.

Where the borehole or well was in close proximity to an electric cable from a power-station, lifting- or forcing-pumps could be arranged to pump from the same by having worm-gearing attached to the motor so as to reduce the speed.

For deep-well pumping, long-stroke pumps were best, there

being less wear-and-tear on the pump, less slip, and naturally a higher efficiency, making altogether a much quieter working plant.

With regard to testing tube-wells, in his (the writer's) opinion, it was a very important matter to have a long continuous pumping test, working the pump night and day, before deciding to lay down a permanent plant. He had recently made such a test at a borehole which he was putting down at Alnwick. The 2-horsepower petrol-engine was belted to a Tangye wheel-lift and force-pump. The plant was run for six days and six nights, with an average yield of 1,320 gallons per hour, from a borehole 2½ inches in diameter. The water was 3 feet 2 inches from the surface when the test was begun, and was lowered to 19 feet 6 inches from the surface at the conclusion. Previous to making this test the writer had urged the parties interested to run the pump for at least a month night and day, pointing out that the water might be coming from an underground reservoir in the jacks of the stone, and not from the absolute spring. From the results above-mentioned, it would be seen that this proved to be the case. The borehole in question was being continued, and a further test would be made before any more money was expended in getting the water to the mains.

In conclusion, he thought that the members were deeply indebted to Mr. Broadhurst for his very capable and instructive paper on a subject which was of increasing importance to the public.

Mr. G. J. Binns (Derby) moved a vote of thanks to the Council of the University of Sheffield for the use of the meeting-rooms; and also to the owners of works and collieries to be visited by the members.

Mr. J. Gerrard (H. M. Inspector of Mines) seconded the resolution, which was warmly approved.

Mr. J. H. Merivale (Broomhill) proposed a vote of thanks to the Midland Institute of Mining, Civil and Mechanical Engineers for the arrangements which had been made for

that meeting, and also to Prof. L. T. O'Shea, who had so ably provided for the comfort and convenience of the members.

Mr. Robert Clive (Bentley Colliery) seconded the proposal, which was heartily carried.

Mr. J. Hamilton (Glasgow) proposed a vote of thanks to Mr. H. C. Peake and Mr. C. E. Rhodes for their services in the chair.

Mr. E. Halse (London) seconded the resolution, which was cordially approved.

The following notes record some of the features of interest seen by visitors to collieries, works, etc., which were, by kind permission of the owners, open for inspection during the course of the meeting on September 4th, 5th, and 6th, 1907:—

DALTON MAIN COLLIERIES, LIMITED: SILVERWOOD PIT.

The shafts, 21 feet in diameter, were commenced in April, 1900, and reached the Barnsley seam at a depth of 2,238 feet in December, 1903.

A considerable quantity of water was met with down to a depth of 450 feet, and was dealt with by pumps slung in chains. These feeders of water now form the water-supply for various colliery purposes, and are dealt with at a separate pit 12 feet in diameter and 450 feet in depth. The pumping-engine is of the horizontal cross-compound trunk type, with cylinders 17 inches and 30 inches in diameter respectively, and 34 inches stroke, and the engines are geared to the plunger-pumps in the proportion of 8 to 1. Each flywheel is 12 feet in diameter, and weighs over 9 tons. The air-pumps, 16 inches in diameter by 17 inches stroke, of the vertical single-acting type, are worked by a direct crank and shaft. The condenser is of the ordinary jet description. The main shaft-pumps are a twin set of plunger-pumps, 18 inches in diameter, at a depth of 450 feet, the stroke being 6 feet. The valves and valve-rings are of cast-steel, and the rings are faced with vulcanite. The wooden spears are 12 inches square, and each joint is flitched by four steel jointing-plates, 16 feet long, 9 inches wide, and ¾ inch thick. The pumping-plant is constructed to lift 40,000 gallons per hour to the surface from a depth of 450 feet when running at 5½ strokes per minute.

Further small feeders were met with down to a depth of 900 feet, which are now dealt with by a three-throw electric pump, with a 20-horsepower motor, which delivers the water from a lodgment at a depth of 900 feet to the main pumps at a depth of 450 feet. The small quantity of water made in the headings and workings generally, is dealt with by three-throw pumps, the lower one with a motor of 30 horsepower forcing against a head of 1,350 feet to a lodge, and then a motor of 20 horsepower forcing against a head of 900 feet to the surface.

The winding-engine at the eastern or upcast pit has two cylinders, 42 inches in diameter and 7 feet stroke, with a winding-drum

20 feet in diameter, and fitted with Cornish double-beat valves and steam reversing-gear. An automatic cut-off is fitted, and will be put into use shortly. The cages, holding eight tubs, are each guided by four locked-coil ropes, and two rubbing-guides are hung between the cages. It is intended to put in a balance-rope. The winding-ropes are of the locked-coil type, 5½ inches in circumference, and the capping is secured by white metal.

The winding-engine at the western or downcast pit has two cylinders 48 inches in diameter and 7 feet 6 inches stroke, with a winding-drum 24 feet in diameter, and fitted with Cornish double-beat valves and steam reversing-gear. The cages, holding twelve tubs, are each guided by four locked-coil ropes, and two rubbing-guides hung between the cages. A round balance-rope, weighing about 6 tons, is used. The winding-ropes are of the ordinary Langs-lay type, 6½ inches in circumference. An hydraulic decking arrangement is in course of construction.

The steel headgears, at both shafts, are 75 feet high from the top of the breastwork to the centre of the pulleys, which are 20 feet in diameter; the main legs are 2 feet square, the corner angles being 5 inches by 5 inches by ⅜ inch.

The ventilation is at present produced by a Schiele fan, 13 feet 4 inches in diameter, belt-driven by a single horizontal engine, with a cylinder 28 inches in diameter and 3 feet stroke. A volume of 200,000 cubic feet of air per minute, at a water-gauge of about 1 inch, is produced, when the fan is running at 56 revolutions per minute.

With the exception of the engines already enumerated, the boiler feed-pumps and some small engines at the coke-ovens, the whole of the subsidiary operations at the colliery, including underground haulage, are carried out by means of electric motors, of the slip-ring unenclosed type, of the following sizes:—7½, 20, 40, 65, and 110 horsepower.

The electrical generating-plant consists of two units at work and one in course of erection: (1) A generator of 350 kilowatts, driven at a speed of 300 revolutions per minute by a cross-compound engine of 600 horsepower, running at 60 revolutions per minute. The high-pressure cylinder is 26 inches in diameter, and the low-pressure cylinder 40 inches, the stroke being 4 feet. Corliss valves are fitted to the high-pressure cylinder and slide-

valves to the low-pressure cylinder. The flywheel, weighing 26 tons, and 20 feet in diameter, is grooved for 24 cotton ropes. (2) A generator of 300 kilowatts, driven by a high-speed compound engine, at 375 revolutions per minute. The three-phase current, at 550 volts, has a periodicity of 50 cycles per second. (3) This, in course of erection, is a generator of 450 kilowatts, which will be driven at a speed of 300 revolutions per minute, by a high-speed engine of 700 horsepower. The switchboard is constructed on a marble base, all the live-metal work being at the back of the frames, so that there is nothing on the front within reach of the attendants except the insulated handles of the terminals of the exciter-circuit. The current for lighting is taken from the three-phase generators and passed through transformers, fixed in the generating-house.

The screens are erected at a distance of 450 feet from the shafts, so as to keep away dust and to provide stock-room for both full and empty tubs. A creeper-chain is provided along the full-tub gantry to take the full coal-tubs to the weighing-machine. They are lifted by another creeper into the tippler-house, containing four tippers of the rotary type, each capable of turning two tubs per time. The screens, of the ordinary shaker type, deliver the coal on to six belts, two for hard coal, two for soft coal, and two for nut-coal. The large-coal belts are fitted with lowering jibs for reducing the fall of the coal into the wagons.

The small coal is carried by conveyor-belts, delivering into a pit, whence it is taken by an elevator to a Baum washer, with a capacity of 130 tons per hour. After washing, the small coal is sorted into three sizes, namely, nuts, peas, and coking small, and loaded direct, into wagons, from the hoppers under the washer.

The coking small, after being crushed, is lifted into a storage-hopper with a capacity of 800 tons. Thence it is taken to a battery of 36 horizontal-flued Simon-Carvès bye-product ovens, producing an average of 800 tons of coke per week. A battery of 44 Simon-Carvès regenerative vertical-flued ovens, in course of erection, will be capable of producing 1,200 tons of coke per week. The usual bye-products, namely, sulphate of ammonia, tar, and benzol, are recovered.

The joiners', fitters', and blacksmiths' shops are in a large building 180 feet long and 40 feet wide, covered by an iron roof.

The lamp-cabin, a brick-building with cement-concrete floor

and roof, may be said to be absolutely fire-proof: the stands, cleaning-tables, etc., being made of iron. The double-glass Thornbury safety-lamps—about 2,200 in number—lighted electrically, are fitted with the Barton burner, and burn a heavy mineral-oil with a flash-point of about 250° Fahr.

The engine-rooms, used for the sinking-engines, are being converted into an electricians' workshop and a store-room for spare parts of machinery.

There are thirteen Lancashire boilers, 30 feet long and 8 feet in diameter, working at a pressure of 120 pounds per square inch, fitted with stokers and self-cleaning fire-bars, the coal being supplied to the latter by a system of elevators and conveyors. Large receivers, connected to three boilers at a time and some 5 feet in diameter, provide an ample reserve of steam. The economizers have a nest of 440 tubes.

The underground haulage comprises two units, each with two surge-pulleys, 6 feet in diameter, fitted with clutch-gear, so that one rope can run independently of the others. Each unit is driven by a slip-ring motor of 110 horsepower. Another unit of similar construction is being erected. The present output is about 2,300 tons a day.

The brickyard is fitted with two semi-plastic machines, each capable of making 10,000 bricks per day. The continuous brick-kiln has fourteen chambers.

HADFIELD'S STEEL FOUNDRY COMPANY, LIMITED, TINSLEY, SHEFFIELD.

The visitors inspected the various shops having a special interest for colliery managers and engineers, the manufacture of steel-castings and specialities for colliery purposes being one of the principal features of the company's business.

The East Hecla Works cover an area of about 80 acres, and comprise the following departments:—Steel-foundry, three machine-shops, colliery wheel-fitting shop, smithy, tub-building shop, ore-crusher and conveyor-erecting shop, pattern-shop, generating-station, etc.

Electric driving is universal throughout the works. The foundry is 1,020 feet long; it is the largest in the world, and its equip-

ment includes twenty-four overhead electric travellers, and fourteen electric jib-cranes. The power-station for supplying electric current for power purposes and for electric lighting is situated in the centre of the works, and consists of seven cross-compound Corliss engines with dynamos and other appliances, forming, in all, seven units, capable of developing an aggregate of 4,000 horsepower.

The machine-shops, four in number, are all of large size, covering an area of about 5 acres. They are fitted with modern machine-tools of the most powerful type, and twenty-two overhead electric-travelling cranes.

Although Hadfield's Steel Foundry Company, Limited, are, as the name of the firm indicates, primarily steel-founders and producers of castings and forgings for all branches of engineering work, they also manufacture certain complete machines which consist chiefly of steel-castings, such as ore-breakers, screening plant, elevators, and conveyors for ore, coal, etc.

Messrs. Hadfields have always made a point of producing special steels for different classes of work, according to the mechanical properties needed for the working conditions. Several special grades of steel which the company manufacture are now wellknown in the colliery and engineering trades throughout the world, perhaps the most prominent and best known amongst engineers being the "Era" manganese-steel, of which the company are the sole makers. The "Era" manganese-steel combines the two qualities of hardness and toughness. The material is so hard that no steel tool will cut it, but it is by no means brittle. On the contrary, it is exceedingly ductile; in fact, so much so, that pieces ½ inch thick can be bent cold nearly double without showing any sign of fracture.

The colliery tub-wheel department is a very important branch of the company's works. Wheels are also supplied in a special grade of their best toughened cast-steel, the total output approximating to 20,000 wheels per week, the bulk of which, before being despatched, are fitted on axles ready for fixing to the tubs.

The visitors were shown the company's patent automatic tub-greaser; and the McBean and Eaton patented tub-controller, for passing one, two, three, and four tubs at a time, retaining or releasing one or more, as may be required, either upon a cage or upon a line of tram-rails.

The Drury patented pedestal and guard is another article manufactured by the company, a device which is especially useful when used in conjunction with the patent tub-greaser. Another colliery-device made by the company is the Sylvester patent prop-withdrawer.*

In connection with mining and colliery-work, may be mentioned the "Heclon" rock and ore-breaker. This is a gyratory stone-crusher, in which the "Era" manganese-steel is used for the crushing parts. With the gyratory arrangement, the motion of the crushing cone is very slight, and this fact, combined with the concave form of the surface against which the stone is broken, and the instant release after cracking, tends to prevent the shattering of the stone and economizes the dust. In many cases macadam or ballast broken in this way is found superior even to hand-broken stone. Another application of the "Era" manganese-steel is found in Hadfield and Jack's patent stone-breaker and ore-crusher, the jaws of which are constructed of this material.

"Era" manganese-steel is also used for the manufacture of revolving screens for grading ore and road-metal, and for elevators and conveyors which are specially designed for economical handling of ore, coal, etc.

In connection with railway work, Messrs. Hadfields make locomotive castings of every description, such as wheel-centres, axle-boxes, horn-blocks, motion-plates, roof-bars for boilers, etc. Complete wheels, tyres, and centres for railway-wagons are also largely supplied, and are taking the place of the wrought-iron wheels for goods stock. The larger wagons now used and the heavier loads demand something more reliable than the older materials, and the company have introduced a special grade of best toughened cast-steel for this purpose. Buffer-castings are also a special feature to which attention has been turned, and a large number of these have been supplied; also a quantity of castings for Laycock patent brakes and couplers.

For hydraulic presses, the company make cast-steel cylinders, rams, and glands, they having been the first to introduce steel-cylinders for hydraulic valves; these are supplied up to 27 feet long, either as castings from the mould or machined and

* "Improved Apparatus for Drawing Timber in Mines," by Mr. Edward B. Wain, *Trans. Inst. M. E.*, 1896, vol. xii., page 591.

finished. These are difficult castings to make, on account of the comparatively thin walls and big heads attached to them, leading to unequal contraction. Some of these castings take as much as 22 tons of metal.

To castings for electrical machinery, special attention has been given, both in regard to the form of castings and to the electrical permeability of the metal. Magnet-rings up to 16 feet in diameter have been cast in one, the weight being as much as 20 tons.

The Hadfield's Steel Foundry Company, Limited, have a special department devoted to the manufacture of "Era" manganese-steel points and crossings for tramways and railways. The company have also completed some extensive and complicated lay-outs for electrical conduit tramways, a branch of engineering to which they have given much attention.

WILLIAM COOKE AND COMPANY, LIMITED: TINSLEY STEEL, IRON, AND WIRE-ROPE WORKS, SHEFFIELD.

The wire-rope factory was erected in 1887, and comprises 60,000 square feet of flooring for machines. It is equipped with machinery for dealing with wire-ropes as used by mines and engineering works. The wire used in the manufacture of the ropes is carefully tested before it is sent into the rope-factory, and detailed records are kept of the manufacture of every rope.

An incline hauling-rope, 19,680 feet long and 1½ inches in diameter, of improved plough-steel, galvanized, weighed over 32 tons. Another rope of the same quality, 12,000 feet long and 1¼ inches in diameter, weighed 14½ tons.

In 1903, a wire-rod mill was erected for rolling high-class wire-rods for rope-wire, card-wire, etc., more attention being paid to the quality than to the quantity of production. The billets are heated in a Siemens gas-furnace. The power-plant for driving the mill consists of a coupled tandem compound condensing engine, constructed to develop 1,200 horsepower when using steam at a pressure of 150 pounds per square inch. The fly-wheel, 17½ feet in diameter, grooved for thirty-two ropes, each 1½ inches in diameter, transmits the power to pulleys on the finishing and intermediate mill-shafts, the cogging-mill being driven by a pulley from the intermediate mill-shaft. The

finishing-mill has a hollow-steel driving-shaft, running at 400 to 500 revolutions per minute. The condensing-plant comprises three vertical air-pumps with a jet-condenser, two compound condensing pumps, a steam-separator, a steam-trap, and a feed-heater through which the water is pumped before entering the fuel-economizer.

The works have a productive capacity of over 20,000 tons of bar-iron per annum, a large portion of this material being their wellknown brands of "Cooke's Best Yorkshire," "Special Crank," "B. B. Cable," and other qualities specially adapted for engineering and colliery purposes. Channel-steel is also rolled in numerous sections for rubber-tyres for all classes of vehicles and motor-cars. Shoes for horses, pit-ponies, carriage, omnibus, van, and heavy dray horses are turned out at a rapid rate by machinery. The old prejudice against machine-made shoes is gradually dying out, this being in a measure due to the great improvements introduced in the manufacture of machine-made shoes.

The works include a chemical laboratory, where all classes of raw and finished materials are analysed; a testing-shop containing a 100-ton hydraulic testing-machine for testing wire-ropes, bar-iron, etc., roll-turning, engineering, boiler-smiths', blacksmiths', joiners', and pattern-making shops.

SAMUEL OSBORN AND COMPANY, LIMITED, SHEFFIELD.

Clyde Steel-works.—The power-station comprises gas-producers and gas-engines. Two Crossley gas-producers of 250 and 150 horsepower respectively are in use. The Tangye three-cylinder vertical Otto cycle gas-motor of 200 horsepower is coupled direct to the dynamo that is used for power purposes. The pistons are 16 inches in diameter by 19 inches stroke, and the engine runs at 210 revolutions a minute. The supply of gas is regulated at the throttle-valve. The engine is started by compressed air at a pressure of 160 pounds per square inch. A horizontal gas-engine of 70 horsepower, with cylinders 16½ inches in diameter and 24 inches stroke, drives a compound-wound dynamo by means of a belt. The circulation of the water through the jackets of the gas-engines is assisted by a

centrifugal pump. A horizontal Corliss engine of about 200 horsepower drives two rolling mills, with rolls 16 and 12 inches in diameter respectively. A beam-engine actuates three rolling-mill trains, with rolls respectively 8, 10, and 12 inches in diameter. In the crucible-steel melting department, there are seven sets of holes of one dozen each.

At the testing-lathe, the capabilities of Mushet high-speed steel for turning tools were demonstrated. A tool, 1¼ inches square, at a cutting speed of 65 feet per minute, with a traverse of ¼ inch, took a cut of 1 inch off the diameter of a large tensile-steel shaft, weighing 40 tons. When taken out for inspection, the tool was found to be perfectly good at the nose.

In the twist-drill department, a Mushet high-speed steel twist-drill, ⅞ inch in diameter, running at 526 revolutions per minute, drilled holes in cast-iron at the rate of 17·02 inches per minute. A drill, 2⅝ inches in diameter, running at 111 revolutions per minute, drilled holes in steel with a tensile strain of 30 tons per square inch, at the rate of 3·58 inches per minute.

Rutland Works.—In 1885, Messrs. Samuel Osborn and Company, Limited, finding it impossible to extend further their Clyde Steel Works to meet the growing demand for some classes of their productions, took a large mill close to Rutland Bridge. It had been occupied by Messrs. Samuel Butcher and Company, and was rebuilt, considerably added to, and adapted as a steel-foundry. It is thoroughly equipped for every class of casting, from motor-car castings of a few ounces to cogging-mill rolls and other large pieces of 20 tons weight.

The members witnessed the tapping and casting of 12 tons of high-permeability steel. Hand, hydraulic, and gear moulding and core-making machines were fully occupied with a large variety of work. A large sand-blast fettling plant has been installed, and a compound air-compressor of the vertical type supplies a system of compressed air at a pressure of 80 pounds per square inch for the working of pneumatic sand-riddles, rammers, chippers, and other tools.

The works are equal to an output of about 200 tons per week, the steel-plant consisting of crucible furnaces and two Siemens acid furnaces, each of 12 tons capacity; and an extensive and up-to-date plant of the converter type was in course of completion.

A varied assortment of incline rollers and frames, pulleys, sheaves, buffer-hoops, rope-clips, pit-turns, tub-wheels, axles and pedestals, and other colliery requisites were being made or awaiting despatch. In addition to the various tempers of carbon-steel required for the many different classes of castings made, from nearly pure iron for dynamo and motor parts to the exceedingly hard qualities required for quartz-crushing machinery, the company also make castings in nickel and chrome-steels; and a speciality is made of manganese-steel for all purposes where extreme hardness combined with toughness is essential.

Brookhill Works.—From the steel-foundry, conveyances took the visitors to the file-works at Brookhill, where every process in the manufacture of files was witnessed. About 10 tons of finished files are turned out at this factory each week.

DERWENT VALLEY WATER-SCHEME.*

The members visited the Derwent Valley waterworks, and made an inspection of the reservoirs at Howdon and Derwent.

* *Trans. Inst. M. E.*, 1904, vol. xxvii., page 274.

COURRIÈRES EXPLOSION: REPORT TO AND OPINION OF THE GENERAL COUNCIL OF MINES.*

At their meeting held on May 3rd, 1907, the General Council of Mines had read to them Inspector-General O. Delafond's report on the Courrières disaster of March 10th, 1906, from which report the following essential facts may be deduced:—

I.—Facts.

On March 10th, 1906, about 6·45 a.m., a mine, which was considered to be one of the least dangerous in the Pas-de-Calais, that of Courrières, was the scene of an explosion of quite exceptional extent, which laid waste the workings of Nos. 2 & 10, 3, and 4 & 11 pits.

Situation of the Devastated Workings.—This assemblage of workings extended from east to west, over a length of nearly 2 miles, and a breadth occasionally approaching a mile. About 1,700 workpeople were employed therein, and the annual output exceeded 800,000 tons. Nos. 2 & 10 pits were in the eastern part of the working area, No. 3 pit in the central part, and Nos. 4 & 11 pits in the western part.

The number of seams worked was eleven, succeeding each other in the following order, from top to bottom:—Julie seam, 4 feet 9 inches; Mathilde seam, 3 feet 7 inches; Augustine seam, 2 feet 2 inches; Cécile seam, 4 feet 1 inch; Sainte Barbe seam, 6 feet; Joséphine seam, 7 feet 5 inches; Marie seam, 7 feet; Amée seam, 3 feet 3 inches; Eugénie seam, 3 feet 3 inches; Adélaïde seam, 4 feet 7 inches; and Intermédiaire seam, 3 feet 3 inches. The Joséphine is the best seam, and next to it may be ranked the Sainte Barbe and Marie seams. The others, besides being thinner, are less advantageous to work.

The actual area of the workings varied considerably, according to the respective seams. The Joséphine and Sainte Barbe seams were worked from all three plants, and the workings ex-

* This report, together with the accompanying opinion of the General Council of Mines, was published in the *Journal Officiel* of August 1st, 1907, and has been translated by Mr. L. L. Belinfante, M.Sc.

tended over a length of nearly 2 miles. The Marie seam was worked in two mutually independent districts, each averaging ¾ mile in length. As to the other seams, the extent of the workings ranged from a maximum of 1¼ miles (Cécile seam) down to a minimum of 300 feet or so (Intermédiaire seam).

North of the pits, the strata dip slightly southward, forming there the *plateures* (or flat seams), while on the south they roll over, forming there the *dressants* or *renversés* (rearers or reversed seams). Thus each pit has on the north and in the centre its series of flat seams, and on the south its inclined or reversed seams.

The principal onsetting places were at the following depths, measured from the surface:—Nos. 2 & 10 pits, 1,116 feet; No. 3 pit, 1,070 feet; and Nos. 4 & 11 pits, 1,086 feet. There was, moreover, in reality one great haulage-level, which with comparatively insignificant variations (1,116 feet, 1,070 feet, and 1,088 feet) extended over the entire area of the workings. This haulage-level was, as will be shown later on, the chief site of the disaster.

Ventilation.—The system of ventilation was very complicated. The No. 3 or central shaft was a downcast shaft: it conveyed air eastwards to No. 2 pit (provided with a Guibal fan), and westwards to No. 4 pit, similarly provided with a Guibal fan. But, in addition, a portion of the air, to the extent of 13,000 or 15,000 cubic feet per minute, re-emerged from the same shaft by means of a bratticed partition, after having served to ventilate a small district lying to the south of the pit.

Apart from the air passed on from No. 3 pit, No. 2 pit received air coming from No. 10 pit. The total volume of air passed through the fan averaged 74,000 cubic feet per minute. The workings of Nos. 2 & 10 pits, which were devastated by the explosion, received air coming from No. 3 pit.

Nos. 4 & 11 pits were ventilated by two air-currents, one of which came from No. 3 pit and the other from No. 11 pit. These currents were split into a great number of subsidiary currents, the course of which was in some cases extremely sinuous, and necessitated the provision of many ventilation-doors.

Fire-damp had not been recorded in the workings which were the scene of the catastrophe of March 10th, 1907, and so naked lights were used in places where, in strict conformity with the

prefectoral enactment of February 8th, 1905, safety-lamps should have been in use.

In all three pits, the explosive chiefly used was No. 1 Favier powder, with small quantities of safety-explosives (grisounite-couche and grisounite-roche) at those spots where some risk was suspected. The chemical composition of No. 1 Favier powder is as follows:—Nitrate of ammonia 88 per cent., and binitronaphthalene 12 per cent. Its temperature of detonation is 2,139° Cent. (3,982° Fahr.).

Methods of Working.—Nature of the Coal.—Working was conducted on the so-called subsidence-of-roof or *foudroyage* system, wherein the void left by the removal of the coal is packed only with such barren rock as happens to be available in the workings. The result was that packing was conspicuous by its absence in the Joséphine, Sainte Barbe, and Marie seams, and was incomplete at best in the other seams.

The coal is fairly rich in volatile matter, the percentage of this varying, according to the seam, from 30 to 35.

The dust arising from these seams is easily inflammable. On several previous occasions at Courrières, ignition of coal-dust had taken place as a consequence of shot-firing with black powder: as, for instance, in May, 1884, Joséphine seam, No. 6 pit; in February, 1895, Sainte Barbe seam, No. 3 pit; and in July, 1895, Joséphine seam, No. 5 pit. This last incident alone had proved serious, the flames having spread over a length of nearly 200 feet, and two workmen having sustained burns. In view of that occurrence, the Courrières Coal Company, on the intervention of the Government mining authorities, gave instructions to use those safety-explosives which are employed in fiery mines. But certain disadvantages were entailed by the use of these explosives—they proved more especially deficient in force. Consequently, they were given up by the Courrières Coal Company in 1902, and No. 1 Favier powder was substituted for them, although it is liable to set coal-dust on fire.

Rescue-work.—Thick clouds of black smoke, pouring out from Nos. 3, and 4 & 11 pits and raising the cages, heralded the disaster above bank. At No. 2 pit, however, no smoke was perceptible at the surface, and the alarm was first given by the men employed at the bottom hanging-on. From No. 10 pit, the

workpeople were able to reach the surface without the slightest difficulty; but in the other pits immediate rescue-operations were imperative. The course followed by these, up to May 8th, was described in full detail in the Report of the Special Committee of which Inspector-General Adolphe Carnot was the Chairman, and that report was published in the *Journal Officiel* of August 11th, 1906.* It seems needless, therefore, to dwell further on the rescue-work, except to mention what happened after May 8th. The operations subsequent to that date consisted partly in continuing to battle with the fire which had broken out in the Joséphine seam after the disaster, and partly in restoring the mine to a serviceable condition.

The workings of No. 2 pit were very soon put in order again, but it was not until June 20th, 1906, after three months of continuous effort, that the abovenamed fire was extinguished.

To No. 4 pit, it was found necessary to devote more prolonged exertions, and it was not until August 4th, 1906, that the workings there were restored to a thoroughly serviceable condition. By that time, the working-parties had ranged through well nigh 70 miles of devastated haulage-ways and workings, and had completed retimbering over a total length of about 7 miles.

In No. 3 pit, on May 16th, 1906, another fire was discovered in the Joséphine seam, to the south of that previously mentioned. Despite strenuous long-continued effort, this new fire has not yet been overcome, and a district where 11 dead bodies are believed to lie is still barred off. On the other hand, in July, the working-parties were enabled to reach the seat of the fire in the Cécile seam. Precautions had been taken, sufficient to determine the extinction of the conflagration if it was still in progress, or if it were to start afresh. It was ascertained, however, that this fire, which had caused so much alarm at one time, was merely an insignificant wood-fire; it had burnt up about 176 cubic feet of timber that was in an advanced stage of dry rot, and had most certainly died out very shortly after the main disaster.

In the course of getting the workings into suitable order again, careful note was taken of all facts that might prove of any possible interest, and it is now proposed to enumerate those facts.

* *Trans. Inst. M. E.*, 1906, vol. xxxii., page 487.

Position of the Bodies.—At No. 2 pit, the effects of the disaster were overwhelmingly instantaneous: in the Joséphine seam, at the 1,116-feet level, as many as 136 workmen were killed on the spot, or as near as makes no difference—the few that made an attempt to flee being struck down within 150 or 200 feet. In other seams, worked indeed at less deep levels, the workmen were able to make a dash for life, and 128 escaped out of a total of 144.

At No. 3 pit, all the workpeople in the 1,070-feet level, north of the shaft, to the number of 189, were killed, three-fourths of them on the spot. The workmen on the 994-feet level and in the workings near the 919-feet level, 94 in number, had a chance of seeking safety in flight, and, in fact, 31 of them did succeed in escaping.

To the south of No. 3 pit, in the flat-seam workings, 89 workmen were killed, and 5 alone escaped. Three-fourths of the victims were killed on the spot, and the others successively collapsed from suffocation as they ran.

In the rearer workings, 66 workmen were able to make some attempt to escape. Two of them only reported themselves at the pit-eye on March 10th; 13 others took refuge in culs-de-sac, and got out on March 30th; while the other 41 were suffocated as they fled, or in endeavouring to shield themselves from the onrush of poisonous gases. The bodies of 14 of these men were found at the end of the bowette at a depth of 1,070 feet, in the bottom drift of the Joséphine seam, between two stoppings which they had endeavoured to make gas-tight with their clothing. This endeavour must have been unsuccessful, as the untouched stores of food which they had with them would imply that they succumbed very quickly.

The 13 belated survivors from No. 3 pit were fortunate enough to escape suffocation, while all around them numbers of workmen rapidly succumbed to the effects of the poisonous gases, and they themselves had witnessed the collapse, by suffocation, after a day or two, of 8 of their mates who had at first joined their party.

The brattice of No. 3 pit having been destroyed, the current which ventilated the southern workings of the Joséphine, Sainte Barbe, and Adélaïde seams was thereby cut off, and it was inevitable that the poisonous gases should sooner or later invade all the culs-de-sac, as they had in No. 4 pit, in the northern district (second division) of the Marie seam, and in the south-western dis-

trict of the Sainte Barbe seam. The reversal of the ventilation, and the resumption of working of the fan at No. 4 pit drawing the air from No. 2 pit, induced, as was ascertained afterwards, the passage of a strong current from No. 2 pit passing south of No. 3 pit into the Cécile seam. The current progressively purified the atmosphere of the entire southern district of No. 3 pit, and, saving the 13 survivors from suffocation, eventually enabled them to leave their place of refuge.

At Nos. 4 & 11 pits, in the 1,086-feet south level, two alone out of 253 workmen escaped; 180 were killed on the spot, and 71 were struck down at various points in endeavouring to escape. In the 1,086-feet north level, 50 workmen out of 210 were killed on the spot, 136 were struck down as they fled (some after they had traversed a considerable distance); 23 were rescued on March 10th, and 1 man, the fourteenth "miraculous survivor," got out on April 4th. In the 1,257-feet level, only 25 workmen out of 159 perished; while in the 981-feet level the 8 men at work there were either killed on the spot, or succumbed after they had gone but a few feet.

On the whole, the extension of the disaster throughout the workings was enormous. Most of the victims were killed on the spot, or perished not far off; and it has been ascertained that only the fourteen "miraculous survivors," referred to by the Special Committee of which Inspector-General Carnot was Chairman, lived for any length of time after the disaster.

Dynamic and Calorific Effects.—Origin of the Explosion.—The great working-level common to the several pits (1,116 feet at No. 2 pit, 1,070 feet at No. 3 pit, and 1,086 feet at No. 4 pit) was all but entirely laid waste by the explosion. The only workings that were undamaged were those south of No. 2 pit, and a few places at the southern and northern extremities of Nos. 3, and 4 & 11 pits, which only experienced the inrush of poisonous gases.

The upper and lower levels, on the other hand, were damaged only in the neighbourhood of the internal shafts by means of which they communicated with the above-mentioned main plane of workings.

The Joséphine seam was the principal seat of the explosion, and it is through one of the levels in that seam that the flames passed from No. 3 pit to Nos. 4 & 11 pits. The Sainte Barbe

and Marie seams were also much ravaged. It is noticeable that in these three seams, as is shown by the all but universal encrustations of coke on the timbering, the flames spread to the far end of the working-places, dealing instantaneous death to the greater number of the miners in their working-places. In the thinner seams, the explosion travelled no perceptible distance: it simply spread for a few yards into the bottom levels.

The ascertained facts, as to dynamic effects, calorific effects, orientation of coke-crusts, and direction in which objects were thrown, form sufficient cumulative evidence as to the undoubted origination of the explosion to the north of No. 3 pit.

District of the Lecœuvre Headings.—Moreover, the observed dynamic effects make it extremely probable that it was in a roadway of the Joséphine seam, the so-called "Lecœuvre heading," that the ignition was started, from a point whence all the projectamenta radiate. This and the parallel heading constitute a cul-de-sac about 650 feet in length, running alongside the important Connétable fault. The calorific effects were intense all along these roads—in the coal-dust there only remained 21 per cent. of volatile matter, while moss-like encrustations of coke mantled the walls from end to end.

The dynamic effects, too, were exceptionally marked. The timbering was all overthrown; air-pipes, 14 inches in diameter, which were ranged along the floor near the side, were seriously damaged; the fourth air-pipe, 66 feet distant from the working-face, was broken into eighty-nine separate pieces; the fourteenth air-pipe, at 115 feet from the face, was broken into eleven pieces; while the other air-pipes were torn open, generally longitudinally along their upper surface at the end turned towards the working-face. The first three air-pipes had been shifted towards the face, while the pieces of the fourth were found scattered in a contrary direction over a space of 40 feet. The sixth air-pipe had been shifted towards the seventh.

All the foregoing indications lead to the inference that an explosion had taken place in the Lecœuvre heading at a point about 33 feet distant from the working-face against the southern wall of the heading.

The falls of stone from the roof which had occurred over a considerable extent were mantled with a coke-encrustation, and so it is evident that these falls were coincident with the explosion.

Three dead bodies were lying at the working-face; a fourth was 65 feet distant therefrom, with the breastbone crushed in, the right arm and right leg 8 feet farther off, the leg lying between the side and the tenth air-pipe, the arm on the other side of the latter. The four bodies bore traces of both internal and external burns.

Course of the Explosion.—It has, then, been assumed that the explosion, starting in all probability from the Lecœuvre heading, was propagated thence throughout the main working-level in the Joséphine, Sainte Barbe, and Marie seams. Everything appears to have taken place as if the coal-dust had been priming-powder scattered in the haulage-roads of these seams, which train of powder had then been fired from the Lecœuvre heading. The ignition seems to have run along the whole "train," without being influenced in any way by the division of the ventilating currents.

From the starting-point, the explosion travelled eastwards, towards No. 2 pit, while another sheet of flame swept on to No. 3 pit, whence it penetrated into Nos. 4 & 11 pits by following a level in the Joséphine seam.

The onward progress of the explosion was in places influenced by various circumstancès which it may be of interest to recall. The naturally damp portions of roadways barred the path of the flames: and so these either made considerable detours, or were definitely stopped at those points. Those portions also of the roadways which were comparatively free from dust (either because but little haulage was done there, or because they were walled and so did not offer much scope for the deposition of dust) in many cases stopped the further progress of the flames. Nor did dust of a conspicuously shaly character favour this progress, a circumstance to which probably the thin seams owe their immunity, as the ripping of the roof or the floor in the haulage-roads of these seams induces the deposition of shaly dust. The return airways generally were unaffected.

On the other hand coke-encrustations over the entire devastated area bear unmistakable witness to the fact that the coal-dust caught fire.

The mining engineers of the district held that the most probable cause of the disaster was a sudden outburst of fire-damp along the Connétable fault, which was, of course, ignited by the

naked light carried by one of the miners in the Lecœuvre heading. But the bursting of the air-pipes is on that hypothesis difficult of explanation, unless one admits certain phenomena of "super-pressure," such as those observed by Mr. Beyling in the Gelsenkirchen experimental gallery. Investigations pursued with the greatest care over a period of two months in pushing on with the Lecœuvre headings had failed, however, to reveal the slightest trace of fire-damp.

A second hypothesis assumed that a shot had ignited the coal-dust, while being unstemmed. A shot, penetrating the coal to a depth of 5 feet, had been prepared with No. 1 Favier powder in the Lecœuvre heading on the eve of the disaster; this having probably missed fire, an attempt may well have been made on the fatal day to unstem it, in order to remove the charge of explosive. But the shot may have exploded suddenly (with very little stemming, if any at all), setting fire to the coal-dust which happened to be especially abundant, on account of the previous use of a Sullivan coal-cutter. As a matter of fact, the back end of a shot-hole, 20 inches deep, was observed at the far end of the cut in the Lecœuvre heading. But to this hypothesis a workman, who had been employed for several days previously in the parallel heading, replied that such "shot-holes" were of frequent occurrence. Moreover, the quantity of coal that should have been hewn or loaded that morning was disproportionate to the quantity represented by the stripping of a thickness of 3¼ feet of coal.

According to a third hypothesis, the gases emanating from the fire in the Cécile seam made their way into the Lecœuvre heading, through a series of fissures resulting from mining operations by which the goaf of the Cécile seam was brought into communication with the workings of the Joséphine seam. Against this hypothesis, however, the following objections may be raised: (1) The comparative insignificance of the fire in the Cécile seam; (2) the practical impossibility for the gases of combustion to reach the Lecœuvre heading without being drawn towards No. 2 pit by the main air-current, or without encountering naked lights; and (3) the negative results of the experiments made with sulphur dioxide. After the re-erection of the barriers which were standing on March 10th, 1906, sulphur dioxide was injected behind them. Its propagation appears to have been rigidly confined to the goaf, and not a suspicion of the odour of the gas was perceptible in any part of the workings.

A fourth hypothesis was suggested, to the effect that a shot, or some other unexplained cause, had set fire to the coal-dust in a roadway adjacent to the Lecœuvre heading. The carbon monoxide thus engendered might then have made its way thither and there caught light at a miner's lamp. But there is not a particle of evidence, not a shred of fact, that can be adduced in support of this hypothesis.

Finally, yet a fifth hypothesis has claimed some partisans, both in France and out of it. A surreptitious store of cartridges, stowed away in the air-pipes or beside them, may have exploded suddenly. Hence the bursting asunder of these pipes, and the extreme violence of the dynamic effects observable in the Lecœuvre heading; whereas, in ordinary fire-damp or dust explosions, the dynamic effects at the starting-point are of no great consequence. It would then be easily explicable how the commotion thus produced threw up the dust over a vast area, and originated a disaster of unexampled magnitude.

But then it would be necessary to admit that a workman, probably the one whose body was found with the limbs torn off, had been handling a parcel of cartridges one of which was ready primed; and it is not quite easy to conceive of any sane person behaving in such a manner.

It must, therefore, be conceded that the actual primary cause of the disaster is impossible of determination, a concession which has generally to be made in the case of all those disasters of which there are no surviving eye-witnesses.

II.—Opinion of the General Council of Mines.

After having deliberated thereon, at its sittings of May 10th and May 17th, 1907, the Council, in so far as the accident in itself and the question of responsibilities are concerned:

Considering that, as will be shown, although it has been found impossible, despite the most sedulous and persevering investigation, to determine the precise cause of the initial ignition which brought about the catastrophe of March 10th, 1906, it is undeniable that the extension thereof was due to the propagation, favoured by various circumstances, of the inflammation of the coal-dust over the entire area of the workings in Nos. 2, 3, and 4 & 11 pits, up to a length of nearly 2 miles and a breadth in places approaching 1 mile;

Considering that, in regard to the initial ignition, although the evidence in its entirety agrees in fixing the starting-point in the Lecœuvre heading without, however, establishing this as an absolutely ascertained fact, it remains impossible to determine whether this ignition was due to a sudden outburst of fire-damp, to the explosion of a shot, or to that of a parcel of explosives, and that suppositions only can be advanced in this regard; that, under these circumstances, neither the use in the Lecœuvre heading of naked lights, instead of the safety-lamps which should, according to Article 74 of the decree of February 8th, 1905, have been used there, nor the use of No. 1 Favier powder instead of the safety-explosives which apparently should have been employed in conformity with the prefectoral enactment of March 25th, 1898, can be with certainty invoked as having in this disaster the relation of cause to effect, or cited as involving responsibility therefor on the part of the company which works the mines;

Considering that it is evident, on the other hand, both from the facts which have been ascertained and from the experiments which have been carried out, that the cause of the disaster cannot be traced to the fire in the Cécile seam; and that this fire, the importance of which had been greatly exaggerated, and against which, moreover, all the necessary precautions had been taken, did not of itself constitute a peril of so dangerous a nature as to forbid access to the mine on the part of the workpeople; that, consequently, under this head no responsibility accrues;

Considering, however, that attention may justly be drawn to certain general arrangements as having in no small degree contributed to accentuate the gravity of the disaster, such, for instance, as the unrestricted communication existing between Nos. 2, 3, and 4 & 11 pits, and the imperfect ventilation, the result both of a system of distribution that was wanting in regularity and of the absence of packing in the main seams; that, in fact, the propagation of the explosion over so widespread an area was largely due to the free intercommunication between the workings of the three pits above mentioned; that, moreover, the number of workpeople suffocated would have been doubtless much smaller, if the ventilating current had been more active and its passage better regulated, in such wise that it could have restarted of itself after the disaster and have swept out the poisonous gases, whereas it was completely disorganised by the

destruction of the brattice of No. 3 pit, as also by the destruction of the numerous ventilation-doors;

But that it must be admitted that the inherent defectiveness of these arrangements was only revealed by the occurrence of the disaster itself; that the Courrières colliery not being a fiery mine, its subdivision into independent districts of limited extent hardly appeared imperative, any more than the regularization of the ventilation, intercommunication between the different pits seeming on the contrary justified by considerations of safety, as allowing of the egress of the workpeople in the event of such an accident as an inrush of water occurring in one of the pits; that, with regard to the danger arising from coal-dust, neither the experiments already made, nor the teachings of practical experience, could have led anyone to suspect the possibility in a non-fiery mine of an inflammation of such magnitude, the explosions of dust alone (in the absence of fire-damp) previously recorded in France having never extended much beyond 260 feet from the starting-point, with the sole exception of the accident at the Decize colliery on February 18th, 1890, when the explosion extended over a distance of 590 feet; that, therefore, these arrangements, however easily they may now appear to lend themselves to criticism in view of their consequences, could not have been reasonably attacked before the disaster;

Is of opinion that the local Government mining engineers have rightly concluded that the matter does not call for judicial proceedings.

With regard to the lessons which may be learnt from the disaster, and to the administrative measures which may necessarily ensue:

Considering that the catastrophe at Courrières has shown that non-fiery collieries may be exposed, by reason of the presence of coal-dust, under circumstances which at present it is impossible to define with precision, to the same dangers as fiery mines; that, consequently, it is advisable henceforward to take the same precautions for all coal-mines as for fiery mines, reserving, however, the faculty to deviate from the rules in those cases where the dust being demonstrably non-inflammable all risk of accident is obviated; that, in regard to the general arrangements involved in the planning-out of workings, it will become necessary in future to take careful account in all these mines of the relative

positions assignable to the different pits of one and the same colliery; to take account of the due separability of the areas of the workings of these pits, and, if occasion calls for it, between the various districts of the same pit, the extent thereof being so defined as to restrict within as narrow limits as possible the consequences of any disaster, separation being ensured, in accordance with the opinion recorded on November 15th, 1906, by the Fire-damp Commission, by iron-doors opening outwards capable of resisting a pressure of at least 1 pound per square foot (5 kilogrammes per square metre), and it should be possible, if and when requisite, to lock these doors from both sides: to take account finally of the methodical distribution of the air-currents which are destined to ensure the ventilation of every district in the pit;

That, following out these ideas, it would appear advisable henceforward to do away with divisional brattices in the shafts, to abandon the subsidence-of-roof or *foudroyage* system of working, or at the very least to proportion the application thereof to the difficulty of securing an adequate amount of packing; that it is advisable also to decree the suppression in all mines of naked lights, as also to decree the exclusive use of safety-explosives, to be ignited by means of special shot-firers;

Considering, moreover, that the measures just enumerated have already been prescribed for all the collieries of the Nord and the Pas-de-Calais, in part by the prefectoral enactments of September 7th and 18th, 1906, and in part as a consequence of the judgment recorded by the Council on November 3rd, 1906, and that the necessary enquiry is now proceeding with a view to their adoption in every mine throughout France;

Considering that, in conformity with the conclusions recited by the Reporter, and the measures regarding the breathing-appliances to be used for rescue-purposes in case of accident having been prescribed by the Ministerial enactment of April 15th, 1907, the question of the dust itself and the remedies to be adopted in regard thereto, as also the question of the safety-explosives that should be used in fiery or dusty mines, still remain to be dealt with;

Considering that, with regard to dust, the investigations consequent on certain recent accidents in the Saare coal-field have shown that if (as in specified parts of the Courrières mines) some-

what lengthy stretches of roadway sufficiently damp appears to have been an obstacle to the spread of ignition, it is by no means a certainty that continuous spraying of such stretches would always suffice to arrest the onward march of the flames; that, in any case, it appears to admit of no doubt that the spraying of dust at fairly long intervals is a delusive precaution, as evaporation accelerated by the ventilating current suffices in the course of two or three hours to nullify the effects of the spray;

Considering, on the other hand, that it would appear from the investigations conducted at Courrières, especially in the thin seams where the dust in consequence of the ripping of the roof consisted of shale as well as of coal and where the inflammation was not propagated, that the "shalification" of coal-dust, or its mixture with any other inert substance, might possibly constitute a practical means of averting the risk of dust-ignition; and that before officially decreeing such measures as the continuous watering of more or less extensive roadways, the utility of which is far from assured, without speaking of the difficulty and inconvenience of more than one kind involved in carrying out such measures, it would seem indispensable that this question should form the object of a special enquiry;

Considering, with regard to safety-explosives, that it is needful to take account not only of the question of limitation of charges, but also of the actual composition of the aforesaid explosives, in relation to which two mutually contradictory theories have been advanced, the products of deflagration being precluded from containing (according to one theory) any combustible gases, for fear of contaminating the atmosphere and increasing the percentage of dangerous elements therein, and being precluded from containing (by the other theory) any combustive gases such as oxygen, these high-temperature gases being likely to ignite any fire-damp or dust that may be present; that it is, therefore, necessary to conduct an investigation into this matter, with the view of determining in a general way which are the safest and at the same time the most advantageous explosives to use in regard to the effect produced;

The Council is of opinion that, other necessary measures having already been prescribed in recent enactments, or being now the object of administrative investigations which are nearing

completion, it is advisable to request the Fire-damp Commission, already engaged moreover in the study of coal-dust as well as in that of explosives, on the one hand to undertake the necessary enquiry and to record its opinion on the question of the dangers arising from coal-dust and the properly applicable remedies, regarded not only from the point of view of the water-spraying system as recommended by the Reporter, but also from the more general point of view set forth in the foregoing observations; on the other hand to make known as soon as possible the Commission's opinion on the question, with which it has already begun to deal, of safety-explosives, their composition, the eventual use of new formulæ, the conditions of their use, and, without waiting for the completion of the enquiry, to make known the Commission's opinion as to the limitation of charges which it would be meanwhile advisable to prescribe for the explosives actually in use;

The Council is further of opinion that, in view of the material already published in foreign countries concerning the Courrières disaster, and in view of the technical lessons to be gleaned from a bare recital of the ascertained facts, it would seem appropriate to devote a memoir in the *Annales des Mines* to this disaster, and Mr. Heurteau, Inspector of Mines, is hereby requested to undertake to prepare such a memoir for insertion in that periodical;

With regard to the rescue-operations and the facts ascertained thereanent subsequent to the closure of the enquiry pursued by the Special Committee of which Inspector-General Adolphe Carnot was chairman; considering that the facts ultimately ascertained concerning the fire which occurred in the Cécile seam prove that conflagration to have been a timber-fire of limited extent, having burnt barely 2 tons of wood, and consequently of infinitely less importance and infinitely less dangerous than had been surmised from the evidence obtained at the outset of the rescue-operations, notably from the testimony furnished by the delegate miner (*délégué mineur*) of No. 3 pit; that such testimony was an *incubus* on all the decisions arrived at, since it induced a belief in the imminence of danger which was far from being as serious as was feared; regretting the obstacles which exaggerated evidence of this kind placed in the way of the uninterrupted continuance of the rescue-operations undertaken immediately after the accident;

Considering that the clearance of No. 3 pit, which the engineers in charge of the rescue-work were blamed for not having pushed on (if need were) by violent means, necessitated, as events proved, no less than thirty-seven days' work, and that with more powerful appliances and under far more favourable conditions than were available at the outset; that it follows that the continuation of this clearance under conditions dangerous for those who would have been employed thereat could not within a reasonable time have conduced to any useful result;

Considering, on the other hand, that, as was afterwards ascertained, it was owing to the reversal of the air-current (so bitterly criticized at one juncture) and to the re-starting of the fan at No. 4 pit, that the atmosphere of the roadways lying south of No. 3 pit was gradually purified, and so enabled the thirteen survivors to leave their place of refuge and reach without danger of suffocation the landing of No. 2 pit;

The Council is of opinion that the facts ascertained subsequent to the enquiry of the above-mentioned Committee prove that the abandonment of the clearance-work in No. 3 pit and the reversal of the air-current were justified by events, and that more especially is it owing to the above-mentioned reversal that the thirteen survivors were ultimately able to escape with their lives;

In what regards, finally, the proposals of reward, formulated on the occasion of the rescue by the Prefect of the Pas-de-Calais, to be given to those in the employ of the mining companies and in that of the Office of Public Works;

Considering that it would be advisable, as complementary to the technical investigation of the matter, that the Council should have an opportunity of investigating these proposals, of estimating the part borne by each in the actual rescue-work, and of formulating its opinion on the subject;

Requests that the documents connected with these proposals be claimed from the Ministry of the Interior by the Ministry of Public Works for communication to the Council.

AGUILLON, CHARGUÉRAUD, CARNOT, NIVOIT, O. DELAFOND, KUSS, TAUZIN, R. ZEILLER.

DEEP BORE-HOLES AS A SOURCE OF ELECTRIC ENERGY.*

By GEHEIMER BERGRAT TECKLENBURG, Darmstadt, Germany.†

Introduction.—By means of deep bore-holes fresh water, mineral waters, oil, natural gas, and even heat can be tapped: why then, for once in a way, should not endeavour be made to extract utilizable electric energy from the earth's interior? In the course of tubing bore-holes, the force of magnetism (as the writer has previously shown) is repeatedly manifested: tubes which penetrated several hundred yards into the earth becoming so strongly magnetized that above-bank big keys would remain hanging to them.

It is wellknown that a measurable electric current begins to flow so soon as electrodes are dipped in variously warmed or concentrated solutions, and are joined up by a conducting wire of copper or other suitable material. There are various fluids in the earth at temperatures and under pressures increasing with depth, and so electric currents must obviously arise therein. Now, it is possible that these temperatures and pressures which increase concurrently with depth below the surface can be most appropriately utilized for obtaining electric energy.

Atmospheric Electricity.—In the universe, it seems probable that enormous electric tension arises owing to variable cosmic influences, and in the atmosphere of this world continual alterations of the charge of electricity are taking place. In fact, electricity, as now known, depends very much on atmospheric electricity. It should consequently during thunderstorms exhibit certain special, though extremely evanescent, phenomena, especially at those points where the thunderbolt strikes the earth. It is known that electric differences between the earth and its atmosphere are always observable.

* A paper read before the Wanderversammlung der Bohringenieure, Hamburg, September 3rd, 1907.

† Translated by Mr. L. L. Belinfante, M.Sc.

Earth-currents.—Just as there are continual currents of air in the atmosphere, so doubtless within the earth there are electric currents continually striving to compensate each other. Armed with appropriate appliances, man may hope to effect this compensation, and so utilize the energy thus produced. In the atmosphere, there is, thanks to the essential co-operation of the sun, a continual play of electric compensatory phenomena. Doubtless the variable illumination of the earth by the sun conditions electric currents constant in direction, if in nothing else. Certain changes in the sun, such as increase in number, distribution, and variability of the sun-spots and streamers, and the occurrence of shafts or pillars of flame and coronal protuberances, have a considerable effect on the electric and magnetic conditions of the earth. The "northern lights" are most probably electrical phenomena. Moreover, atmospheric electricity must influence permanently the course of those electric currents which arise within the globe under the action of the sun's rays and the torsion of the earth-magnet. Earth-currents, especially during a period of frequency of "northern lights," affect the telegraph-wires and other electric conductors, whether above or below-ground, and often disturb the operation of the telegraphic apparatus for several hours on end.

Historical.—Many authors have already busied themselves with atmospheric and terrestrial electricity. It was as long ago as 1752 that Benjamin Franklin made experiments with his "electric kite." In 1862, Prof. Lamont buried two plates of metal in the earth at some distance apart, and connected them up with a wire, placing a galvanometer in the circuit. He observed electric currents in the wire which were strongest when the plates lay in the earth in a direction coincident with the magnetic meridian. Mr. Niaudet wrote a treatise dealing with the galvanic elements both terrestrial and marine, and his book was translated into German in 1881 by W. P. Hauck. In 1900, Prof. Weinstein published a book on earth-currents within the territory covered by the German Imperial telegraphs.

In 1901, Prof. Förster published an article* on research directed to earth-currents. Mr. Emil Jahr, of Berlin, started a number of experiments along the lines therein suggested, and

* *Elektrotechnische Zeitschrift*, 1901, page 332.

published the results* in 1902. He conducted his experiments on some level ground at Berlin over distances extending to about 3,300 feet. The soil there presented the following section: made ground, 1 foot; dune-sand, 6½ feet; coarse-grained sand, 3¾ feet; marly loam, 11 feet; coarse-grained drift-sand, 5¼ feet; fine valley-sand, 23¾ feet; sand, 19 feet; drift-sand, 61¼ feet; total, 131¼ feet. The sheet-iron and sheet-zinc plates were 6½ feet long, 3¼ feet broad and 1 foot thick; the copper conducting-wire was 0·04 inch in thickness, and was soldered to the plates, and insulated with isolite, indiarubber, and tarred yarn. On the southern plates, the wire was secured with clamping-screws. The plates were fixed vertically in the ground, and the earth stamped down around and over them. Measuring-instruments were inserted in the circuit, and observations were recorded at various seasons and at various times of the day and night. Plates and also pipes of iron and zinc were sunk in the earth to depths of 3¼, 10, 23, 33, and 131 feet, in the direction of the magnetic meridian and at the angle of magnetic inclination, at various distances from a plate which was buried only to a depth of 3¼ feet. The buried plates were cleaned from oxides, and slightly smeared with a coating of grease.

Mr. Jahr summarized the results of his investigation as follows:—

(1) If two plates of the same metal (or of electrodic carbon) of equal area be so placed in damp earth that the northern plate lies deeper down than the southern, then the electric current which flows through the wire connecting the two plates is of higher tension than when both plates lie at the same depth in the earth or in water.

(2) The highest possible tension and power of current in the wire connecting plates buried in earth or submerged in water is attained when the northern plate lies in relation to the southern in the magnetic meridian and at the angle of magnetic inclination.

(3) Tension in the wire connecting two plates of similar material and similar dimensions is as great, if these lie in earth or water at the same depth in the direction of the magnetic meridian but 1,300 feet or so apart, as if the northern were only 7 feet distant from the southern plate but lay 16½ feet deeper

* *Elektrotechnische Zeitschrift*, Berlin, 1902, part 10.

down than it, that is, at the magnetic angle of inclination in relation thereto.

(4) Tension and power in the current flowing through the wire connecting two plates which lie in the earth along the magnetic meridian and at the magnetic angle of inclination are constant quantities.

(5) If two plates of similar material be so placed in the earth, along the magnetic meridian, that the southern plate lies noticeably lower down than the northern, then the current through the wire connecting these plates flows from north to south, that is, in the reverse direction.

(6) Tension and power of the current flowing through the wire that connects any two plates of similar material buried in earth or submerged in water, are greater when that material approximates more closely to the negative end (copper) than when it approximates to the so-called positive end (zinc) of the "electric tension series."

(7) The power of the current flowing through the wire that connects two plates increases on the whole in the same ratio as the area and thickness of the plates, but more especially with the increase in area of the southern plate.

(8) Between two plates of similar dimensions sunk to a similar depth in the earth, but of dissimilar materials (as, for example, carbon and zinc), the current in the connecting-wire always flows from the carbon to the zinc. The tension of the current in the wire connecting two plates of similar dimensions but dissimilar materials is higher, if the so-called negative plate lies on the south, than if the positive plate lies there.

(9) A film of oxide, even minutely thin, on metal-plates which are buried in earth or submerged in water, has for a long period a considerable disturbing influence on the tension and the power of the current that flows through the wire connecting these plates; and its effects are such that, in the case of two plates of similar material whereof one, however, is (even only in part) coated with a thin film of oxide, while the other is quite free from oxide, the current invariably flows from the oxidized to the unoxidized plate.

(10) By so arranging two pairs of plates of similar material, separated one from the other by thin layers of earth or such like, that the southern pair in relation to the one north of it lies

along the magnetic meridian and at the angle of magnetic inclination, the respective currents may be "added together." But even between pairs of plates which are not placed at the magnetic angle of inclination, a multiplication of tension up to a certain point may be secured.

Mr. K. A. Lotz, of Charlottenburg, has expressed views* which were partly in accord with the foregoing observations.

Experiments.—The work of previous authors was not the main incentive to experiments on the writer's part, as he had independently conceived the idea of utilizing electric earth-currents. He initiated experiments in various bore-holes many miles distant from subterranean electric wires. The first bore-hole, only 46 feet deep, was filled up to a quarter of that depth with water, and tubing was conspicuous by its absence. The second bore-hole, 184 feet deep, was filled up to within 53 feet of the top with water, and iron tubing had been inserted to a depth of 151 feet.

The apparatus consisted of a leaden cylinder, 6 inches long and 2 inches in diameter; or, instead, of two brass female screws, about 4 inches in external diameter and 2·4 inches in internal diameter. Moreover, a brass rod, 2 feet long and 0·4 inch in thickness, was used. For connecting-wires, a dark-grey covered copper-wire, 0·04 inch in diameter, insulated with wax, 328 feet long, and a similar light-grey covered wire, 230 feet long, were used. A voltmeter and an ammeter, and also a small resistance-coil, were set up in the master-borer's cabin. As the leaden cylinder was let down by the wire into No. 1 bore-hole, and the brass rod was buried in damp earth, 165 feet away, the measuring-instruments, having been inserted in the circuit, registered 0·06 volt and 0·001 ampère. When the brass screws were let down No. 1 bore-hole instead of the leaden cylinder, and were then connected up to the brass rod buried in the ground, the voltmeter registered 0·16 volt and the ammeter 0·001 ampère. If the iron tubing was connected up with one end of the wire in lieu of the brass rod, the voltmeter registered 0·24 volt and the ampère-meter 0·001 ampère. But the direction of the current was the opposite of what it had been previously, so that a reversal had to be made at the voltmeter. If the brass screws together with the brass rod were used, then the voltmeter indicated 0·14 volt.

* *Ungarische Montan-Industrie- und Handels-Zeitung*, Budapest, July 1st, 1906.

The results proved that a mass sunk in the deeper bore-hole (184 feet), when connected up with a mass buried near the surface, showed a noticeably greater difference of potential than a similar mass sunk in the 46 feet bore-hole and connected up with the earth-buried mass. Depths of 130 and 160 feet do not show very considerable divergence from the result obtained at the surface, but it seems probable that very different conditions are prevalent at depths of 3,000 to 5,000 feet. Masses of metal may be sunk to various depths in bore-holes, mines, wells, or other excavations. Among the factors which variously affect the electric current are:—(1) The variety of metallic substance, the shape, and especially the size of the masses; (2) the shape, diameter, and depth of the bore-holes, and whether these are quite clear or filled up with detritus; (3) the topographical altitude of the points where the bore-holes have been put down, the distance from springs, rivers, lakes, and seas; (4) the dryness or dampness of the bore-holes, and whether these are partly or wholly filled with fluids; (5) the relations of temperature and pressure in the bore-holes, especially at the bottom (hot molten rocks and particularly metals are imagined as existing in the interior of the earth); (6) nature of the rocks passed through, as for example, clay, sand, gravel, shale, sandstone, limestone, ore, coal, rock-salt, etc.; (7) nature of the fluid in the bore-hole, whether ordinary water, mineral water, brine, or petroleum, etc.; (8) distance apart of the metallic masses, and situation of the bore-hole with respect to the magnetic meridian and the magnetic angle of inclination; (9) the nature, and especially the character of the insulation, of the conducting wires; (10) the character of the tubing in the bore-holes and of the method of working in mines; (11) the meteorological conditions of the atmosphere, cloud-formation, atmospheric electricity (as, for example, in thunderstorms, or during drought at various seasons); (12) earthquakes and volcanic eruptions; and (13) the position of the planets, and their influence on the earth, etc. Moreover, the living energy of the earth's rotation must have some influence on the energy of the electric earth-currents.

The most notable difference between the writer's experiments and those conducted by Mr. Jahr lies therein, that Mr. Jahr sank tubes down to a depth of 130 feet or thereabouts in the earth and connected them up with a wire to the surface, a procedure which the writer would expressly desire to avoid. His idea would be

to sink a tube 3,000 or even 5,000 feet down, and use it for tapping the earth-currents up to a height of 65 feet or more, then to conduct the current upwards by means of a wire completely insulated from the bottom of the bore-hole or from subterranean waters, after having drawn out all the tubing whereby a possible neutralization of the electricity as between the upper and lower earth-layers might be brought about. Of course, account must be taken of the ohm-resistance in the long conducting-wire.

Further Experiments.—The writer is unfortunately not able to complete the necessary experiments, as the deep bore-holes in which such experiments would have to be made are not at his disposal. But boring-syndicates, or any enterprising individual who undertakes boring on a large scale, should attack the problem. The very depth of the bore-holes would allow them to conduct investigations in a great variety of rocks and at very different levels.

The trouble involved is inconsiderable: one needs only to sink a hollow copper-cylinder, 60 feet or more in length, down a bore-hole 3,000 feet or more in depth, while a similar copper-cylinder is buried in damp earth at the surface in the vicinity of the bore-hole. The two cylinders should be connected up by a properly insulated copper-wire, and by inserting at a selected point the necessary measuring-instruments the ampères and volts could be measured. If the current proves powerful enough, an accumulator may be charged with it, and the generator of power, heat, and light is ready made.

In the writer's opinion, the utilization of electric earth-currents is likely to be most successful where masses of very great dimensions are employed, and one of them sunk to considerable depths. A bore-hole is in existence going down to 6,560 feet, and several bore-holes going down to depths between 4,600 and 5,600 feet are on record, whilst bore-holes extending beyond 3,000 feet in depth are no longer of rare occurrence. At such depths, temperatures varying from 104° to 144° Fahr. have been recorded, and pressures varying from 100 to 200 atmospheres.

The diameter of the hollow cylinder should be such that it can fall clear down the hole to the very bottom, and there remain erect, and also such that it can be with ease drawn up again. The ordinary external diameter could range from 2 to 4 inches, as bore-holes that go down to depths of 3,000 to 5,000 feet have usually a

diameter quite as large as that. The copper-cylinder let down the bore-hole alone constitutes the collecting surface; it consists of unscrewable lengths of $3\frac{1}{4}$ to $26\frac{1}{4}$ feet, with a roughened surface, an example of which is furnished by the Pollak accumulator-batteries. The uppermost length should have a knob for securing the copper-wire properly insulated from water or brine. There should be no soldering-points, either on the cylinder or on the knob, on account of the electro-chemical action of two different metals. The cylinder-lengths should, then, consist of drawn-copper piping, and the knob should be hammered out of the piping or bound to it by copper-thread. The collecting-surface might be enlarged at will.

One might, too, connect up the sunken mass with the earth-buried mass at the surface, by means of two insulated copper-wires. It seems quite possible that a very considerable electric current could be obtained, by connecting up a considerable length of iron-tubing in a bore-hole by means of an insulated wire with a mass buried in damp earth at the surface.

At mineral-water baths, the bore-holes are often put down very close together, and provided with tubing of similar or of different metals: for example, iron or copper. If two such lengths of tubing be connected up by an insulated wire, and measuring-instruments be introduced into the circuit, it would seem quite possible (even so) to record very important observations regarding electric earth-currents.

Various Metals.—Naturally, it would be advisable, in making further experiments, to use only similar metals. If different metals were used, just as in a galvanic element, electric currents conditioned by the very difference of the metals would arise in any event, and thus would hamper the attempt to ascertain whether purely terrestrial currents were present. If masses of dissimilar metals be used, that nearest the negative end of the tension-series must be buried at the southernmost point, and that nearest the positive end at the northernmost point. The "galvanic tension-series" has the following order: zinc, lead, tin, iron, copper, mercury, silver, coal, and graphite. Zinc is electrically positive, copper negative. The farther apart any two metals are in this series, the greater is their electrical difference. Say that the difference of tension between zinc and copper is 100, then that between zinc and iron would be 74·7, and that between iron

and copper 31·9. In damp earth, it is possible to form galvanic elements of enormous dimensions, and perhaps to utilize for that purpose any available accumulations of metalliferous ore.

It is a question of considerable importance whether the masses of dissimilar metals be submerged in fluids, and, if so, in what fluids. Water occurs in most bore-holes, and in some are mineral waters, carbonated or uncarbonated, while in others brine, often very strong brine, occurs. Petroleum and other hydrocarbons also are important factors.

In order, then, to obtain a really powerful current when utilizing dissimilar metals, it would be necessary: (1) to see that one of the masses is of very large dimensions, perfectly clean, and lowered to the greatest depth possible below the surface; (2) to use for these masses two metals which are as far as possible apart in the tension-series; (3) to have the second mass also of very large dimensions, and, having cleaned it thoroughly, to bury it in damp earth at the surface; and (4) to connect up both masses by means of a properly insulated copper-wire, inserting a galvanometer in the circuit.

Insulation.—Great importance must attach to the proper insulation of the conducting wire. Indiarubber is perhaps the best insulating material in water, even in brackish water. Cables in which lead is used as an insulating-material are less suitable for these experiments.

Conclusion.—All bore-holes, and especially the deeper ones, should be the object of more thorough practical and scientific investigation. More experiments should be carried out in them, and this would open up a prospect of utilization of the unsuccessful deep borings on which so much money has been wasted.

It is, perhaps, needless to add that other methods than those herein proposed can and will be applied to the utilization of the electric energy stored up in the depths of the earth. The writer merely wished to suggest that experiments directed to that end should first of all be started in deep bore-holes, and then in deep-mine workings. He is himself perfectly ready to join in the experiments, if invited to do so.

Taking prospects at their best and their worst, what could happen? In the most favourable event, sources of power, heat, and light, would be revealed in the depths of the earth, of incal-

culable importance for the whole of mankind. In the most unfavourable event, a few scores of pounds would have been thrown away on the experiments. The appliances used would still possess most of their intrinsic value, after the experiments, as before. If good results were obtained, rights could be applied for and worked.

The characteristics of the earth's magnetism, its declination, inclination, and horizontal intensity, have been determined with great precision in many localities. Why not devote interest as keen to the far more important problem of the earth's electricity? The Government authorities themselves ought to direct their attention to the matter.

Down to such depths as 3,000 feet and more, masses of metal have never yet been sunk in the manner herein foreshadowed. It is, therefore, impossible so far to criticize unfavourably the possibilities of electric phenomena at such depths. But it is highly probable that, given the necessary appliances, much electric energy is to be obtained from the earth. It is only by experiment that the proper method of doing so can be discovered. The writer feels assured that a brilliant future awaits the investigators who will set themselves seriously to work at this problem, the solution of which is worthy of the efforts of the noblest minds.

EXPERIMENTS ON AN AUXILIARY VENTILATING FAN.*

By the late M. WALTON BROWN.

I.—Description of the Experiments.

The writer, by the courteous permission of Messrs. Bell Brothers, Limited, and Mr. A. L. Steavenson, was enabled to make the experiments on auxiliary ventilation set forth in this paper.

The Browney colliery was ventilated by a Schiele fan, 8½ feet in diameter, placed at bank, exhausting air from the Hutton, Busty, and Brockwell coal-seams. The air from the Hutton seam was restricted by the use of a regulator, placed near the upcast shaft (fig. 1, plate xi.).

The auxiliary ventilation was produced by a Schiele fan, 5 feet in diameter, situated in the Busty coal-seam, near the upcast shaft.

The experiments were conducted under conditions similar to those set forth in the Report on Mechanical Ventilators,† and the results are contained in Table I.

* This paper was read at the General Meeting of the Institution held in London on May 24th, 1901, and gave rise to the accompanying discussion. As the paper in its then form, however, was hardly ready for printing in the *Transactions*, its publication was postponed. Although Mr. Walton Brown fully intended that his paper, over which he had spent much time and trouble, should eventually appear in the *Transactions*, his wish was not gratified during his lifetime. After his death, on November 22nd, 1907, the present editor of the *Transactions* invited Mr. H. W. G. Halbaum to undertake the task of going through the MS. of the paper with a view to his arranging the same for publication. This Mr. Halbaum gladly undertook to do as an office of love; and it is, therefore, owing to this gentleman's kindness that the members are able to have on record Mr. Walton Brown's valuable communication on auxiliary ventilation.

It should be added that Mr. Halbaum is thoroughly familiar with the author's ideas on the subject. With regard, however, to that part of the paper which is contained in Appendix II., he is not quite sure whether the author equally approved of this section, and it has, therefore, been thought advisable not to commit Mr. Brown to the opinions contained in it; and it is printed as a "Note."—Editor.

† "Mechanical Ventilators: Report of the Committee of The North of England Institute of Mining and Mechanical Engineers and the Midland Institute of Mining, Civil and Mechanical Engineers," by Mr. M. Walton Brown, *Trans. Inst. M. E.*, 1899, vol. xvii., page 482.

TABLE I.—SOME PARTICULARS OF EXPERIMENTS ON BANK AND BUSTY FANS.

Conditions of Experiment.	No. of Experiment	Bank Fan.					Busty Fan.				Brockwell Seam		Brockwell and leakages, except Busty Seam
		Revolutions of Fan.	Revolutions of Engine.	Volume.	Water-gauges I.	Water-gauges II.	Revolutions of Fan.	Revolutions of Engine	Volume.	Water-gauge.	Volume.	Water-gauge.	Volume.
Ordinary conditions	1	50⅝	12⅛	22,574	+0·009	+ 0·050	0	0	?	?	?	?	?
" "	2	0	0	22,18	+0·094	+ 0·170	0	0	?	?	?	?	?
" "	3	146¾	35	46,74	0·560	0·337	0	0	20,202	0·266	19,052	0·350	26,546
" "	4	222⅞	53	69,234	1·366	0·855	0	0	30,112	0·500	29,896	0·800	39,122
" "	5	282⅝	67½	87 720	2·281	1·500	0	0	37,349	0·750	28,359	1·160	50,371
Door open at pit-top	6	231⅛	55⅛	109,796	1·144	0·358	0	0	17,511	0·211	?	?	?
Orifice of 6 square feet in drift drawing from mine.	7	194⅛	46½	66,870	2·523	2·961	0	0	13,977	0·150	12,835	0·200	52,893
Ordinary conditions	8	0	0	17,313	— +0·156	+ 0·179	202¼	44⅛	18,097	0·200	2,934	0·080	— 784
" "	9	0	0	25,276	+0·200	+ 0·225	282¾	62¾	25,246	0·380	891	0·100	30
" "	0	0	0	28,760	— +0·251	+ 0·290	335	74¾	30,592	0·520	nil	0·120	— 1,732
" "	11	153⅛	36⅝	54,463	0·579	0·295	204⅝	45	26,658	0·315	18,091	0·380	27,805
" "	12	217	51⅝	71,438	1·249	0·761	193⅛	42⅛	30,467	0·431	26,613	0·660	40,971
" "	13	285⅝	68	79,205	2·315	1·504	187½	41½	36,053	0·579	35,536	1·200	43,152
" "	14	154¼	36¾	56,613	0·505	0·241	282⅝	62¾	31,027	0·419	16,275	0·350	25,586
" "	15	230	54⅝	77,748	1·288	0·773	285⅞	63⅛	36,816	0·500	25,810	0·680	40,932
" "	16	279⅝	66⅝	91,648	2·039	1·268	288⅛	64½	39,800	0·740	32,236	1·050	51,848
" "	20	288¾	68¾	93,560	2·296	1·401	272¼	60⅛	39,312	0·725	32,637	1·100	54,238
" "	17	140⅞	33⅛	56,738	0·354	0·090	344¼	76⅞	34,002	0·542	13,062	0·235	22,736
" "	18	224	53½	77,001	1·204	0·675	339⅛	75¾	37,287	0·664	24,500	0·660	39,714
" "	19	273⅛	65⅛	90,599	1·986	1·150	333⅝	74½	41,114	0·810	30,839	0·920	49,485

Nos. 1 to 5 experiments were made at various speeds of the bank fan, varying from zero to 282⅜ revolutions per minute. It will be noticed that in Nos. 1 and 2 experiments the water-gauge showed the existence of pressure in the fan-drift.

No. 6 experiment was made with the doors open at the surface, producing a volume of 109,796 cubic feet of air per minute. In No. 7 experiment the air was drawn through an orifice of 6 square feet, erected in the fan-drift.

In Nos. 8, 9, and 10 experiments the bank fan was standing, and the Busty fan was run at varying speeds, and in each experiment there was a pressure of ¼ inch measured by the water-gauge.

In Nos. 11, 14, and 17 experiments the bank fan was run at about 150 revolutions per minute, and the Busty fan at the same varying speeds.

In Nos. 12, 15, and 18, and 13, 16, and 19 experiments the bank fan was run at about 225 and 280 revolutions per minute respectively, and the Busty fan at the same varying speeds.

The natural ventilation of the mine was considerable, and amounted to 22,183 cubic feet of air per minute, as measured in No. 2 experiment; and the ventilation was not materially increased when the bank fan was running at 50⅞ revolutions per minute.

The mean results of Nos. 3, 4, and 5 experiments, made upon the bank fan, show that, when running alone, it exhausted from the Busty coal-seam about 135 cubic feet of air per revolution and from the rest of the mine about 178⅓ cubic feet per revolution, the total volume being 313⅓ cubic feet per revolution; the volume at the low speed was somewhat greater and at the high speed somewhat less.

From Nos. 8, 9, and 10 experiments upon the Busty fan, it appears that, when running alone, it exhausted about 90 cubic feet of air per revolution from the Busty coal-seam.

Certain of the experiments exhibit abnormal results. In No. 8 experiment, although the Busty fan ran at 202¼ revolutions per minute, the recorded volume (17,313 cubic feet) is less than that produced by natural ventilation (22,183 cubic feet). The volume produced in the Busty coal-seam, however, agrees with the results of other experiments, so that it is probable that there has been an error in measuring the volume of the air in the fan-drift.

In No. 13 experiment, the volume of air in the Busty coal-seam (36,053 cubic feet) is less than that produced by the bank fan, when running alone (37,349 cubic feet), although the Busty fan was running at a speed of 187½ revolutions per minute. The bank fan, run at nearly 286 revolutions, should have produced (286 × 135 =) 38,600 cubic feet of air per minute in the Busty coal-seam, without any assistance from the Busty fan; but the volume produced in the Busty seam, with both fans running, was only 36,053 cubic feet per minute. The Busty fan alone, at a speed of 187 revolutions, would only produce about (187 × 90 =) 17,000 cubic feet per minute; and it is evident, therefore, that it actually retarded the ventilating current induced by the bank fan, and acted as a regulator. It will be seen from Table II. that in this experiment 192 cubic

TABLE II.—COMPARISON OF THE EXPERIMENTS, ASSUMING THREE GIVEN SPEEDS OF THE BANK FAN.

No. of Experiment.	Bank Fan.			Water-gauges.		Busty Fan.		
	Revolutions per Minute.	Volume of Air in Cubic Feet.	Volume per Revolution in Cubic Feet.	I.	II.	Revolutions per Minute.	Volume of Air in Cubic Feet.	Volume of Air per Revolution in Cubic Feet.
8	0	17,313	–	+	+	202¼	18,097	89·48
9	0	25,276	–	+	+	282⅝	25,246	89·29
10	0	28,760	–	+	+	355	30,592	91·32
3	150	47,783	318·56	0·585	0·352	0	20,649	—
11	150	53,222	354·81	0·553	0·282	197⅞	26,050	130·44
14	150	55,053	367·02	0·478	0·228	274½	30,172	109·88
17	150	60,413	402·75	0·401	0·102	366½	36,204	98·78
4	225	69,894	310·64	1·392	0·871	0	30,409	—
12	225	74,072	329·21	1·343	0·818	200¼	31,592	157·76
15	225	76,058	338·04	1·233	0·740	279⅝	36,016	128·78
18	225	77,345	343·75	1·215	0·697	341	37,454	109·83
5	280	86,982	310·65	2·243	1·475	0	37,035	—
13	280	77,645	277·30	2·225	1·445	183½	35,343	192·54
20	280	90,715	323·98	2·159	1·317	264	38,121	144·40
16	280	91,771	327·75	2·044	1·271	289	39,853	137·96
19	280	92,753	331·26	2·082	1·205	341½	42,091	123·33

feet of air were drawn through the Busty fan per revolution, which would increase the resistance of that fan to 4½ times that due to the normal volume of 90 cubic feet per revolution, and produce a loss of pressure which would not be compensated by the low speed of the Busty fan.

Nos. 1 and 2 experiments, in view of the mean volume of 313⅓ cubic feet per revolution, suggest that for a fan to move with an already induced current and in the same direction, without actually impeding that current, the fan must move at such a velocity that the mean current due to the speed of the fan should not be less than 70 per cent. of the volume of the current previously existing. In other words, if the first current is produced by a pressure, h, the velocity of the auxiliary fan must not be less than that corresponding to a pressure $h/2$. Nos. 12, 13, 16, and 20 experiments appear to confirm this conclusion, which may be supported by further experiments.

In No. 13 experiment, the decrease in the total volume is much greater than that of the volume in the Busty coal-seam, so that it is very probable that there has been a considerable error in reading the anemometer. This opinion is confirmed by the water-gauge and by the volume of the air in the Brockwell seam. The decrease of the volume of air in the Busty seam does not account for the decrease in the total volume, and, consequently, the abnormal decrease of the total volume of 79,205 cubic feet could only be due to an abnormal decrease of air circulating through the Hutton seam. The mean volume of the ten experiments in which both fans were running at the same time shows that the ratio of the volumes in the Hutton seam to the Brockwell seam was about 6:10; and in none of the remaining nine experiments is the ratio less than 5:10. If the measurements of the volumes in No. 13 experiment are correct, the ratio in that experiment must have fallen to 2:10, a decrease of 60 per cent. Although the running of the fan in the Busty seam would affect the volumes of air in the Brockwell and Hutton seams, and their ratio to the volume in the Busty seam, it could scarcely affect their ratio to each other. If it be assumed that in No. 13 experiment, as in all the others, the volume in the Hutton seam was about five- or six-tenths of the volume in the Brockwell seam, and the total volume be proportionately corrected, the abnormal decrease of volume disappears, and the total volume becomes about 90,000 cubic feet per minute, and falls into line with the natural sequence of the volumes (see Table I.).

II.—Comparison of the Experiments.

The various speeds of the bank fan approximate to 150, 225, or 280 revolutions per minute. In order that the experiments may be directly compared, each speed has been reduced to the standard speed to which it most closely approximates, and the other observations of the experiments have been similarly reduced. The results of these calculations are shown numerically in Table II. and graphically in fig. 2 (plate xi.).

The speed of the bank fan being maintained constant during each series, it will be seen that as the speed of the Busty fan increases, the volume of air in the Busty seam and the total volume increase; and the readings of the water-gauge, upon which the ventilation of the Brockwell and Hutton seams depend, diminish, whilst the volume of air decreases in these seams.

The speeds of the Busty fan, in the various experiments, approximate to 200, 280, or 340 revolutions per minute. The speeds, volumes, and water-gauges have been reduced to one or other of these speeds, and the results are shown numerically in Table III., and graphically in fig. 3 (plate xi.).

Table III.—Comparison of the Experiments, assuming three given Speeds of the Busty Fan.

No. of Experiment.	Bank Fan. Revolutions per Minute.	Bank Fan. Volume of Air in Cubic Feet.	Bank Fan. Volume per Revolution in Cubic Feet.	Water-gauges. I.	Water-gauges. II.	Busty Fan. Revolutions per Minute.	Busty Fan. Volume of Air in Cubic Feet.	Busty Fan. Volume of Air per Revolution in Cubic Feet.
8	0	17,120	–	+	+	200	17,895	89·48
11	150¼	53,298	354 81	0·554	0·283	200	26,087	130·44
12	224¾	73,981	329·21	1 340	0·816	200	31,552	157·76
13	305	84,598	277·30	2·641	1·716	200	38,508	192 54
9	0	25,030	–	+	+	280	25,000	89·29
14	153	56,137	367·02	0·497	0·237	280	30,766	109·88
15	225¼	76,150	338·04	1·236	0·742	280	36,060	128·78
16	271½	88,948	327·75	1·921	1·194	280	38,627	137·96
20	297	96,213	323·98	2·429	1·482	280	40,431	144·40
10	0	29,189	–	+	+	340	31,048	91·32
17	139¼	56,042	402·75	0·345	0·088	340	33,585	98·78
18	224⅓	77,114	343·75	1·208	0·677	340	37,342	109·83
19	278¾	92,330	331·26	2·063	1·194	340	41,900	123·33

The effect of running the Busty fan at higher speeds is similar to the removal of a regulator from the Busty seam, the

total volume and the volume in the Busty being increased, while the volume circulating in the other parts of the mine is decreased.

In the same mine, the volume of ventilation is proportional to the cube-root of the power of the ventilation. Consider the Busty-seam ventilation at first by itself. When the bank fan acts alone, it produces (for the Busty seam) a ventilating pressure of p pounds per square foot, and a volume of v cubic feet of air per minute. The work per minute done on the Busty air by the bank fan is, therefore:

$$F=pv \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

When the Busty fan acts alone, it produces a pressure, p, and a volume, v, and the power in the air is:

$$f=p_1 v_1 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

When both fans act together, it is evident that the total power in the Busty air will be $F+f$, and this power will set up a pressure, P, and circulate a volume, V, which gives us three values for the power in the air at this stage, namely:

$$F+f=pv+p_1 v_1=PV \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Now, if $$PV=pv+p_1 v_1\,;$$

then, $$V^3 \times \frac{P}{V^2}=v^3 \times \frac{p}{v^2}+v_1{}^3 \times \frac{p_1}{v_1{}^2} \quad . \quad . \quad (4)$$

But, in the same mine:

$$\frac{P}{V^2}=\frac{p}{v^2}=\frac{p_1}{v_1{}^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Therefore, dividing both sides of equation (8) by this constant value, we have:

$$V^3=v^3+v_1{}^3 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

and $$V=\sqrt[3]{v^3+v_1{}^3} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Now, if the bank fan makes a revolutions per minute and the Busty fan makes b revolutions, we have, from the preceding data, the mean theoretical volume for the Busty seam equals:

$$\sqrt[3]{(135a)^3+(90b)^3} \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This is the theoretical Busty volume given in column 4 of Table IV., and this value is the ordinate of the curve AB in fig. 4 (plate xi.).

In Table IV. all values have been reduced to values corresponding with a constant speed of 100 revolutions per minute of

the bank fan. The theoretical Busty volumes are calculated by formula (8), and their curve being AB in fig. 4 (plate xi.), the experimental volumes are shown by the irregular curve, AC. The curve of the actual volume follows the theoretical curve as closely as can be expected from the nature of the case. The broken red line, AD, shows the Busty volume due to the bank fan acting alone, and the line, OE, shows the volume when the Busty fan acts alone at the speed shown as abscissa. The line, AF, follows the sum of these volumes, which some wrongly imagine should be yielded by the combined action of the fans; but it will readily be recognized that the final volume is really that volume which corresponds with the total power at work on the air. This volume is defined by equation (8), and it is ordinate to the curve, AB.

Table IV.—Comparison of the Experiments, assuming one constant Speed of the Bank Fan.

No. of Experiment.	Revolutions per Minute.		Busty Seam: Volume of Air in Cubic Feet.		Total Volume of Air in Cubic Feet.	
	Bank Fan.	Busty Fan.	Theoretical.	Actual.	Theoretical.	Actual.
13	100	65½	13,900	12,600	31,730	27,730
12	100	89	14,400	14,100	32,230	32,920
20	100	94	14,500	13,600	32,330	32,400
16	100	103¼	14,800	14,200	32,630	32,780
19	100	122	15,600	15,000	33,430	33,130
15	100	124	15,700	16,000	33,530	33,800
11	100	133	16,100	17,400	33,930	35,480
18	100	151⅔	17,100	16,700	34,930	34,380
14	100	183	19,100	20,100	36,930	36,700
17	100	244½	23,600	24,100	41,430	40,300

It is a mathematical consequence of equation (8) that the *maximum* volume obtainable from two fans in tandem is 26 per cent. greater than the volume obtainable from one. For if $n_1 = n_2$, then $N = \sqrt[3]{n_1{}^3 + n_2{}^3}$ is 26 per cent. greater than n_1 or n_2. But if n_1 be greater than n_2, then $\sqrt[3]{n^3_1 + n^3_2}$ exceeds n_1 by less than 26 per cent. This is well seen in fig. 4 (plate xi.). At 150 revolutions of the Busty fan, the Busty fan and the bank fan are, so far as the Busty volume is concerned, equal in power, and AB at this particular point is 26 per cent. higher than AD and OE. At less than 150 revolutions of the Busty fan, AB is never 26 per cent. higher than AD, and beyond 150 revolutions AB is never 26 per cent. higher than OE.

(Of course the volume due to the sum of two powers may exceed the volume due to the *lesser* power by much more than 26 per cent.)

The theoretic total ventilation in column 5 of Table IV. is obtained as follows:—It consists of the theoretic Busty volume +17,830 [see formula (8)]. The curve, LM, in fig. 4 (plate xi.) has been drawn to this ordinate. But it is evident that, as the relative Busty volume increases, and the bank water-gauge diminishes, the volume per 100 revolutions of the bank fan drawn from the rest of the mine must tend to fall below 17,830 cubic feet, and the total volume will fall below LM. Similarly, this diminution of the relative volume from the rest of the mine will tend to push the actual Busty volume above AB. Both of these tendencies are evident in fig. 4 (plate xi.). The actual total volumes are plotted on LN. The abnormal drop of LN at experiment 13 has been referred to, and a probable solution offered. If that solution be admitted, it will be seen that the actual volumes on LN cling very tenaciously to their theoretical path along LM.

The mean results of the experiments were as follows:— The ratio of the Busty-fan revolutions to the bank-fan revolutions being increased from 0 (in experiments Nos. 3 to 5) to 2·445 (in experiment No. 17), the Busty volume rose 78 per cent., the total volume rose 28 per cent., whilst the ventilation of the Brockwell and Hutton seams fell 9 per cent. The theoretical law* that the volume is in ratio to the cube-root of the power is confirmed, and the experiments prove that the law holds good even when the total power is obtained from two separate fans. But the speed of the rear fan must not unduly lag behind the speed of the other. Whether two separate ventilating installations are as economical as one single installation designed for the entire work is another question.

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* All the above formulæ are mathematically deducible from the Atkinsonian equation, $pa = ksv^2$. – H. W. G. H.

TABLE V.—COMPARISON OF THE EXPERIMENTS, SHOWING THE MUTUAL RELATIONSHIP OF THE HORSEPOWER OF THE ENGINES, THE SPEED OF THE FANS, AND THE VOLUMES OF AIR PRODUCED.

Number of Experiment.	*Bank Fan-engine.* Inches. Diameter of piston, 15⅝; Do. piston-rod, 2½; Length of stroke, 30 (No back rod.)				*Busty Fan-engine.* Inches. Diameter of piston, 10½; Do. piston-rod, 1½; Length of stroke, 18 (No back rod.)				Total Indicated Horsepower $=P+p$. m % from bank fan and n % from Busty fan.			Ventilation of Busty Seam. TV=theoretic, and MV=actual volume of air.		Ventilation from Rest of Mine. Theoretical and Actual Volumes		TOTAL VENTILATION.				Number of Experiment.
I.	II.				III.				IV.			V.		VI.		VII.		VIII.	IX.	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11) Value of m.	(12) Value of n.	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	
Expt.	Revs	St.	P.	Value of x.	Revs.	St.	p.	Value of y.	$P+p$.	m.	n.	TV.	MV.	TV.	MV.	Calculated Volume.	Actual Volume as measured.	Error of Estimate.	Remarks.	
3	35	7·81	7·9	12·9	0	0	0	0	7·9	100	0	20,102	20,202	26,646	26,546	46,748	46,748	—	—	3
4	53	15·83	24·2	13·7	0	0	0	0	24·2	100	0	29,771	30,112	39,463	39,122	69,234	69,234	—	—	4
5	67¼	24·32	47·0	14·3	0	0	0	0	47·0	100	0	37,740	37,349	49,980	50,371	87,720	87,720	—	—	5
13	68	24·62	48·3	14·3	41¼	8·89	2·8	1·91	51·1	95	5	39,265	36,053	50,497	43,152	89,762	79,205	13 per cent	Abnormal result.	13
12	51⅝	15·16	22·5	13·7	42½	9·00	2·8	1·91	25·3	89	11	31,050	30,467	38,590	40,971	69,640	71,438	2½ "	—	12
20	68¾	24·98	49·4	14·3	60½	15·66	7·0	2·33	56·4	88	12	41,775	39,312	50,880	54,238	92,655	93,550	1 "	—	20
16	66⅝	23·36	44·8	14·3	64½	16·96	8·1	2·33	52·9	85	15	41,225	39,800	49,246	51,848	90,471	91,648	1 "	—	16
19	65½	24·23	45·5	14·3	74½	20·61	11·4	2·41	56·9	80	20	43,000	41,114	49,497	49,485	92,497	90,599	2 "	—	19
15	54⅝	16·98	26·8	13·7	63½	15·72	7·4	2·33	34·2	78	22	35,940	36,816	40,840	40,932	76,780	77,748	1 "	—	15
18	53¼	15·76	24·2	13·7	75¾	21·03	11·8	2·41	36·0	67	33	38,005	37,287	39,566	39,714	77,570	77,001	1 "	—	18
11	36⅝	8·28	8·7	12·9	45	?	?	?	?	?	?	?	26,658	27,531	27,805	?	54,463	—	No diagrams for Busty fan-engine.	11
14	36¾	8·59	9·1	12·9	62¾	16·56	7·7	2·33	16·8	54	46	30,110	31,027	27,963	25,586	58,073	56,613	2½ per cent.	—	14
17	33½	6·97	6·7	12·9	76½	20·43	11·7	2·41	18·4	36	64	32,742	34,002	25,251	22,736	57,993	56,738	2 "	—	17
8	0	0	0	0	44½	9·25	3·1	1·91	3·1	0	100	18,097	18,097	—	—	18,097	17,313	—	—	8
9	0	0	0	0	62¾	14·74	6·9	2·33	6·9	0	100	25,246	25,246	—	—	25,246	25,276	—	—	9
10	0	0	0	0	74¾	21·06	11·9	2·41	11·9	0	100	30,592	30,592	—	—	30,592	28,760	—	—	10

REFERENCES.

St. = Mean steam-pressure per square inch on piston.
P = Indicated horsepower of bank fan-engine.
p = Indicated horsepower of Busty fan-engine.
Theoretical volume for Busty seam $=\sqrt[3]{4{,}300^3 xP+10{,}000^3 yp}$.

Theoretical volume for rest of mine $=5{,}700\sqrt[3]{xP}$.
Calculated total ventilation = theoretical Busty volume + theoretical volume for rest of mine.
$x=12·9$, or $13·7$, or $14·3$, according as the speed of the bank fan is low, medium, or high, respectively.

$y=1·91$, or $2·33$, or $2·41$, according as the speed of the Busty fan is low, medium or high, respectively.
The variation of the speed affects the ratio of the mechanical and fluid frictions, and also that of the mechanical and natural ventilations.

APPENDIX I.—TABLE I.—Comprising the whole of the Data foregoing

Type of Ventilator	Schiele.		
Date .. 1889	July 27th.		
Time	12·30 p.m.	12·48 p.m.	2·15 p.m.
No. of Experiment	1	2	3
Condition of Mine	Mine under ordinary working conditions.		
Temperature, atmosphere, wet, degs. Fahr.	58	58¼	59½
„ „ dry, „	67	67¾	69½
„ in fan-drift, wet, „	67½	68¾	65½
„ „ dry, „	70	71	67½
Pressure of atmosphere, inches of mercury	29·43	29·43	29·46
BANK FAN.			
Results of Observations:—			
Duration of experiment, minutes	8	8	8
Mean revolutions of engine, per minute	12·125	0	35
„ „ fan, per minute	50·875	0	146·750
„ „ anemometer, per minute	314·125	308·375	656·750
Water-gauge at inlet of fan, No. I., inches	− 0·009	− 0·094	0·560
„ „ fan-drift, — feet from fan No. II., inches	− 0·050	− 0·170	0·337
Indicator diagrams:—			
Mean pressure, pounds per square inch:—			
Back-end	(1) 3·625	..	(4) 8·065
„	(2) 3·728	..	(5) 8·149
„	(3) 3·184	..	(6) 8·508
„ average	*3·512*	..	*8·240*
Front-end	(1) 2·405	..	(4) 7·190
„	(2) 2·505	..	(5) 7·309
„	(3) 2·542	..	(6) 7·634
„ average	*2·484*	..	*7·378*
Average	*2·998*	..	*7·809*
Steam pressure, pounds per square inch	45	45	42·1
Results of Calculations:—			
Mean velocity of air, feet per minute	317·5	312	657·5
Mean volume of air, cubic feet per minute	22,547	22,183	46,748
Motive power of engine, horse-power	..	0	7·9
BUSTY FAN.			
Results of Observations:—			
Temperature in Busty Seam, degs. Fahr.	*	*	56
Duration of experiment, minutes	..	..	8
Mean revolutions of engine, per minute	0	0	0
„ „ fan, per minute	0	0	0
„ „ anemometer, per minute	*	*	568·5
Water-gauge at inlet of fan, No. III., inches	*	*	0·266
Indicator Diagrams:—			
Mean pressure, pounds per square inch			
Back-end	..	..	..
„	..	..	..
„	..	..	..
„ average	..	..	..
Front-end	..	..	..
„	..	..	..
„	..	..	..
„ average	..	..	..
Average	..	..	..
Results of Calculations:—			
Mean velocity of air, feet per minute	*	*	568·75
Mean volume of air, cubic feet per minute	*		20,202
Motive power of engine, horse-power	..	..	..
BROCKWELL SEAM.			
Results of Observations:—			
Temperature in Brockwell Seam, degs. Fahr.	*	*	75½
Duration of experiment, minutes	..	..	12
Mean revolutions of anemometer, per minute	*	*	268·583
Water-gauge No. IV., inches	*	*	0·330
Results of Calculations:—			
Mean velocity of air, feet per minute	*	*	272·75
Mean volume of air, cubic feet per minute	*	*	19,052

* No observations recorded.

COLLECTED BY THE LATE M. WALTON BROWN IN THE COURSE OF THE EXPERIMENTS.

Schiele.						
July 27th.						
2·30 p.m.	2·45 p.m.	3·0 p.m.	3·45 p.m.	6·0 p.m.	6·20 p.m.	7·15 p.m.
4	5	6	7	8	9	10
Mine under ordinary working conditions.		Air admitted freely from Atmosphere by opening doors at Surface.	Return Airway to Ventilator closed, with the exception of an opening of 6 sq. feet.	Mine under ordinary working conditions.		
58 68 64 66½ 29·45	58 69 63½ 65½ 29·45	58 68 61 65½ 29·45	57 67 66 68½ 29·46	56 63 70½ 73 29·45	55½ 62½ 71 73½ 29·45	55 61 73 75 29·45
8 53 222·875 986·5 1·366 0·855	8 67·250 282·375 1,261,375 2·281 1·500	8 55·125 231·5 1,597·25 1·144 0·358	8 46·250 194·125 951·5 2·523 2·961	8 0 0 238·75 - 0·156 - 0·179	8 0 0 352·625 - 0·200 - 0·225	8 0 0 402·25 - 0·251 - 0·290
(7) 16·854 (8) 16·212 (9) 16·197 *16·421* (7) 14·996 (8) 15·178 (9) 15·538 *15·237* *15·829* 42	(10) 23·508 (11) 26·045 (12) 24·397 *24·650* (10) 23·548 (11) 23·702 (12) 24·691 *23·980* *24·315* 43	(13) 19·305 (14) 18·840 (15) 19·366 *19·170* (13) 17·319 (14) 19·060 (15) 18·400 *18·260* *18·715* 42	(16) 13·574 (17) 14·016 (18) 14·656 *14·082* (16) 12·852 (17) 12·611 (18) 13·122 *12·862* *13·472* 45	.. ..	.. ..	.. ..
973·75 69,234 24·2	1,233·75 87,720 47·0	1,544·25 109,796 ..	940·5 66,870 ..	243·5 17,313 ..	355·5 25,276 ..	404·5 28,760 ..
57 8 0 0 855 0·500	57 8 0 0 1,068·125 0·750	58 8 0 0 492·125 0·211	58 8 0 0 391·25 0·150	57 8 44·500 202·25 508·75 0·200	57 8 62·750 282·75 713·5 0·380	57 8 74·750 335 869 0·520
.. ..	.. ..	.. ..	.. ..	(19) 7·301 (20) 8·293 (21) 8·789 *8·128* (19) 10·603 (20) 10·729 (21) 9·799 *10·377* *9·252*	(22) 14·930 (23) 14·513 (24) 13·767 *14·403* (22) 13·091 (23) 15·267 (24) 16·862 *15·073* *14·738*	(25) 18·922 (26) 20·683 (27) 20·702 *20·102* (25) 22·294 (26) 21·593 (27) 22·192 *22·026* *21·064*
847·75 30,112 ..	1,051·5 37,349 ..	493 17,511 ..	393·5 13,977 ..	509·5 18,097 3·1	710·75 25,246 6·9	861·25 30,592 11·9
70 12 426·416 0·800	67 12 404·083 1·160	* .. * *	79 12 177·75 0·200	73 12 29·25 0·080	72 12 2·583 0·100	73 12 Nil. 0·120
428 29,896	406 28,359	* *	183·75 12,835	42 2,934	12·75 891	Nil. Nil.

APPENDIX I.—TABLE I.—*Continued.*—COMPRISING THE WHOLE OF THE DATA FOREGOING

Type of Ventilator	SCHIELE.		
Date .. 1889	July 28th.		
Time	12·0 noon.	12·30 noon.	1·0 p.m.
No. of Experiment	11	12	13
Condition of Mine	Mine under ordinary working conditions.		
Temperature, atmosphere, wet, degs. Fahr.	58½	58½	57½
" " dry, "	64½	65½	65½
" in fan-drift, wet, "	70	68½	67½
" " dry, "	72	71	69
Pressure of atmosphere, inches of mercury	29·50	29·50	29·50
BANK FAN.			
RESULTS OF OBSERVATIONS:—			
Duration of experiment, minutes	8	8	8
Mean revolutions of engine, per minute	36·625	51·625	68
" " fan, per minute	153·5	217	285·625
" " anemometer, per minute	770·375	1,019·125	1,134
Water-gauge at inlet of fan, No. I., inches	0·579	0·761	2·315
" " fan-drift, — feet from fan, No. II., inches	0·296	1·249	1·504
Indicator Diagrams:—			
Mean pressure, pounds per square inch:—			
Back-end	(28) 8·181	(31) 15·590	(34) 25·426
"	(29) 9·284	(32) 16·245	(35) 22·930
"	(30) 9·789	(33) 16·146	(36) 24·631
" average	*9·085*	*15·994*	*24·326*
Front-end	(28) 7·199	(31) 14·341	(34) 24·196
"	(29) 7·339	(32) 14·538	(35) 24·826
"	(30) 7·901	(33) 14·129	(36) 25·749
" average	*7·479*	*14·336*	*24·924*
Average	*8·282*	*15·165*	*24·625*
Steam pressure, pounds per square inch	40	40	42
RESULTS OF CALCULATIONS:—			
Mean velocity of air, feet per minute	766	1,004·75	1,114
Mean volume of air, cubic feet per minute	54,463	71,438	79,205
Motive power of engine, horse-power	8·7	22·5	48·3
BUSTY FAN.			
RESULTS OF OBSERVATIONS:—			
Temperature in Busty Seam, degs. Fahr.	58	56	56
Duration of experiment, minutes	8	8	8
Mean revolutions of engine, per minute	45·000	42·500	41·250
" " fan, per minute	204·375	193·125	187·25
" " anemometer, per minute	754·5	865·25	1,029·75
Water-gauge at inlet of fan, No. III., inches	0·315	0·431	0·579
Indicator diagrams:			
Mean pressure, pounds per square inch:—			
Back-end	..	(31) 8·835	(34) 8·665
"	..	(32) 8·930	(35) 8·227
"	..	(33) 8·504	(36) 8·332
" average	..	*8·756*	*8·408*
Front-end	..	(31) 9·764	(34) 9·451
"	..	(32) 8·945	(35) 9·173
"	..	(33) 9·013	(36) 9·513
" average	..	*9·241*	*9·379*
Average	*	*8·998*	*8·893*
RESULTS OF CALCULATIONS:—			
Mean velocity of air, feet per minute	750·5	857·75	1,015
Mean volume of air, cubic feet per minute	26,658	30,467	36,053
Motive power of engine, horse-power	*	2·8	2·8
BROCKWELL SEAM			
RESULTS OF OBSERVATIONS:—			
Temperature in Brockwell Seam, degs. Fahr.	77	72	66
Duration of experiment, minutes	8	8	8
Mean revolutions of anemometer, per minute	254·5	378·5	508
Water-gauge, No. IV., inches	0·380	0·660	1·200
RESULTS OF CALCULATIONS:—			
Mean velocity of air, feet per minute	259	381	508·75
Mean volume of air, cubic feet per minute	18,091	26,613	35,536

* No observations recorded.

COLLECTED BY THE LATE M. WALTON BROWN IN THE COURSE OF THE EXPERIMENTS.

Schiele.						
July 28th.						
3·20 p.m.	3·40 p.m.	4·0 p.m.	4·20 p.m.	4·40 p.m.	5·0 p.m.	5·20 p.m.
14	15	16	17	18	19	20
Mine under ordinary working conditions.						
56½	57	56	56½	58½	57	57
64½	63½	63	61	62½	62½	62
70	69	68½	72	70	69	68
72½	21	70	74	72	71	70
29·50	29·50	29·50	29·50	29·50	29·50	29·50
8	8	8	8	8	8	8
36·750	54·750	66·625	33·500	53·250	65·125	68·70
154·25	230	279·625	140·875	224	273·5	288·75
801·5	1,112·5	1,320·625	803·75	1,101·25	1,305	1,349·5
0·505	1·288	2·039	0·354	1·204	1·986	2·296
0·241	0·773	1·268	0·090	0·675	1·150	1·401
(37) 9·550	(40) 17·300	(43) 24·146	(46) ..	(49) 16·706	(52) ..	(55) 24·000
(38) 8·894	(41) 17·584	(44) 20·362	(47) 7·855	(50) 15·215	(53) 22·282	(56) 20·727
(39) 9·600	(42) 17·472	(45) 23·318	(48) 7·041	(51) 12·567	(54) ..	(57) 27·485
9·348	*17·452*	*22·575*	*7·448*	*14·829*	*22·282*	*24·071*
(37) 8·131	(40) 16·306	(43) 24·041	(46) ..	(49) 16·361	(52) ..	(55) 26·627
(38) 8·147	(41) 16·681	(44) 24·779	(47) 6·496	(50) 16·676	(53) 26·187	(56) 25·039
(39) 7·229	(42) 16·780	(45) 23·608	(48) 6·496	(51) 17·043	(54) ..	(57) 25·000
7·836	*16·589*	*24·143*	*6·406*	*16·693*	*26·187*	*25·889*
8·592	*17·020*	*23·359*	*6·972*	*15·761*	*24·234*	*24·980*
44	43	..	42	42	42	..
796·25	1,093·5	1,289	798	1,083	1,274·25	1,315·75
56,613	77,748	91,648	56,738	77,001	90,599	93,550
9·1	26·9	44·8	6·7	24·2	45·5	49·4
58	58	58	58	58	58	58
8	8	8	8	8	8	8
62·750	63·500	64·125	76·875	75·750	74·500	60·500
282·375	285·875	288·5	344·25	339·5	333·625	270·25
881·75	1,052·25	1,141	969·25	1,066·375	1,180·25	1,126·5
0·419	0·500	0·740	0·542	0·664	0·810	0·725
(37) 15·680	(40) 14·816	(43) 16·041	(46) ..	(49 20·378	(52) 20·207	(55) 14·350
(38) 15·200	(41) 15·671	(44) ..	(47) ..	(50) ..	(53) 20·634	(56) 15·233
(39) 14·949	(42) 15·450	(45) ..	(48) 20·923	(51) 21·483	(54) 21·030	(57) 14·781
15·276	*15·312*	*16·041*	*20·923*	*20·930*	*20·623*	*14·788*
(37) 18·283	(40) 14·907	(43) 17·875	(46) ..	(49) 19·739	(52) 20·670	(55) 16·794
(38) 16·658	(41) 17·381	(44) ..	(47) ..	(50) ..	(53) 18·265	(56) 16·415
(39) 18·585	(42) 16·103	(45) ..	(48) 19·937	(51) 22·519	(54) 22·820	(57) 16·375
17·842	*16·130*	*17·875*	*19·937*	*21·129*	*20·585*	*16·528*
16·559	*15·721*	*16·958*	*20·430*	*21·029*	*20·604*	*15·658*
873·5	1,036·5	1,120·5	957·25	1,049·75	1,157·5	1,106·75
31,027	36,816	39,800	34,002	37,287	41,114	39,312
7·7	7·4	8·1	11·7	11·8	11·4	7·0
79	73½	67½	76½	74	68½	66½
8	8	8	8	8	8	8
228	368·875	460	181	348	439·875	466
0·350	0·680	1·050	0·235	0·660	0·920	1·100
233	369·5	461·5	187	350·75	441·5	467·25
16,275	25,810	32,236	13,062	24,500	30,839	32,637

APPENDIX I.—TABLE II.

Dimensions, etc., of the Bank Fan.

Description	centrifugal fan of Schiele type.
Diameter	8 feet 4 inches.
Width, at inlet	?
„ at periphery	?
Diameter of inlet	?

Dimensions, etc., of the Engine.

Number of cylinders...	one.
Diameter of the piston	$15\frac{5}{8}$ inches.
„ of piston-rod, fore-end	$2\frac{1}{8}$ „
„ „ back-end	no back rod.
Mean effective area of the piston	190 square inches.
Stroke of piston	30 inches.
Ratio of transmission	by belting, about to 1.

Sundry Particulars.

Area of place of measurement	71·10 square feet.

Dimensions, etc., of the Busty Fan.

Description	centrifugal fan of Schiele type.
Diameter	5 feet 0 inches.
Width, at inlet	?
„ at periphery	?
Diameter of inlet	?

Dimensions, etc., of the Engine.

Number of cylinders...	one.
Diameter of the piston	$10\frac{1}{4}$ inches.
„ of piston-rod, fore-end	$1\frac{1}{2}$ inches.
„ „ back-end	no back rod.
Mean effective area of the piston	$81\frac{1}{2}$ square inches.
Stroke of piston	18 inches.
Ratio of transmission	by belting, about to 1.

Sundry Particulars.

Area of place of measurement	35·52 square feet.

Sundry Particulars relating to Brockwell Seam.

Area of place of measurement	69·85 square feet.

Note.—This Table is evidently incomplete, but the particulars lacking are not really essential to the understanding of the paper.—H.W.G.H.

APPENDIX II.—Note by H. W. G. Halbaum.

Comparative Efficiency of the System.

In making any comparison of the expenditure of power and the results in volume of air when one or two fans are operated, it is necessary to be cautious. If the efficiency of one fan acting alone be *a*, and the efficiency of a second fan acting alone be *b*, it is evident that when both act together the combined efficiency will lie between *a* and *b*. And it will more closely approach *a* on the one hand or *b* on the other hand, accordingly as the one fan or the other contributes the greater proportion of the total power. But such variations of efficiency are due to the relative merits of the two fans, and must not be set down as evidence either for or against the system of dual as against the system of single ventilation. Again, if one fan acts upon an equivalent orifice which is greater or less than that acted upon by the second fan, the results of this difference in the orifice areas must be taken into account before we can pass any final judgment as to whether the observations justify or condemn the use of a secondary fan. And yet again, since the aërodynamic power varies with the speed at a faster rate than the power expended on the passive resistances of the machinery, the effect on the efficiency produced by fluctuation in the speeds must not be lost sight of. Hence, to sum up, if fictitious results are not to be deduced in any comparison of the efficiencies obtained under the two systems referred to, we must, as far as possible, eliminate from our general results those particular results which are solely due to the relative merits of the two fans, or to the relative sizes of the equivalent orifices on which the fans act, or to the different speeds at which they revolve. For none of these particular results is peculiar to the system of ventilating by one fan or to the system of ventilating by two. The character of the machinery, its speed of rotation, and the area of the equivalent orifice will affect the efficiency, whether we ventilate the pit with one fan or with a dozen. These considerations account for the form of Table V. In that table we notice what each fan will do by itself, what it will do by itself at different speeds, and to what extent the equivalent orifice affects the results.

From experiments Nos. 3 to 5, it will be seen that when the

bank fan acts alone, the total volume of air is V when the horse-power is P, and

$$V = 10{,}000\ \sqrt[3]{xP} \quad . \quad . \quad . \quad . \quad . \quad . \qquad (1)$$

where $x = 12{\cdot}9$, $13{\cdot}7$, or $14{\cdot}3$, accordingly as the speed of this fan approximates to 150, 225, or 280 revolutions per minute respectively. In each case, the volume drawn from the Busty seam is about 43 per cent. of the total, from which it is evident that the equivalent orifice of the Busty seam is about 43 per cent. of the equivalent orifice of the entire mine. Hence the Busty volume, when the bank fan acts alone, is, say:

$$v_1 = 0{\cdot}43\,V \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (2)$$

And the volume obtained under the same circumstances from the rest of the mine is:

$$v_2 = 0{\cdot}57\,V \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (3)$$

The Busty fan, as already shown, acts upon an equivalent orifice the area of which is but 43 per cent. of that acted upon by the bank fan, but experiments Nos. 8, 9, and 10 give us an idea of what this fan will do on this orifice. When the horse-power of the Busty fan-engine is p, the volume obtained when the Busty fan acts alone is v_3; and—

$$v_3 = 10{,}000\ \sqrt[3]{yp} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (4)$$

where $y = 1{\cdot}91$, $2{\cdot}33$, or $2{\cdot}41$, accordingly as the speed of the fan approximates to 200, 280, or 340 revolutions per minute respectively. Hence, if there is no waste of power, and if the ratio of the shaft-friction to the friction in the Busty airways remains practically constant—and the insufficiency of the data rather obliges one to act on this unwarrantable assumption—the Busty volume, when both fans act together, should be:

$$v_4 = \sqrt[3]{v_1^{\,3} + v_3^{\,3}} \quad . \quad . \quad . \quad . \quad . \quad . \qquad (5)$$

And the total volume V_2 obtained when the power is $P+p$ should be:

$$V_2 = \sqrt[3]{v_1^{\,3} + v_3^{\,3}} + v_2 \quad . \quad . \quad . \quad . \quad . \qquad (6)$$

The figures in Table V. have been calculated by these formulæ. It seems necessary to draw attention to the following considerations:—When the bank fan acts alone, the Busty volume occupies 43 and the volume from the rest of the mine 57 per cent. of the shaft-area; but when both fans act together, the Busty volume is increased and the area available for the passage of the volume from the rest of the mine is reduced to

something under 57 per cent. of the shaft-area. It is natural to expect that this practical contraction in the effective shaft-area will tend to reduce the ventilation from the quarter indicated, and render it less than 57 per cent. of the theoretical volume due to the bank fan. On the other hand, when the Busty fan acts alone, the Busty volume has the whole thoroughfare in the shaft to itself. When the fan at bank joins in, the volume from the rest of the mine claims part of that thoroughfare. Hence, when both fans act together, the theoretical Busty volume due to the Busty fan will be somewhat less than that deduced from the work of the Busty fan when acting alone. So that, having regard to the total volume when both fans are working, these factors of miscalculation will tend to neutralize each other. That is to say, when the error in the estimate of the Busty volume is *plus*, the error in the estimate of the volume from the remainder of the mine will be *minus*, and *vice versa*. It is therefore to be expected that whilst the calculated volumes for the districts may diverge considerably from the actualities, the total calculated volume, which is the sum of the district volumes, and the sum of a plus error and a minus error, will depart very little from the actual volume as measured, always providing, of course, that the theory of the calculations is sound. The results herewith tabulated (see Table V.) exhibit these features very markedly. The total volume as calculated approaches the actual volume as measured very closely indeed, the error, with one exception, never reaching 3 per cent. At the same time, it must be admitted that the calculated district volumes diverge from the actual volumes less than might have been very reasonably expected.

But the whole investigation shows very clearly that, whether one or two fans be employed, power in the air is obtained for power in the cylinders. The employment of an auxiliary fan neither wastes power unduly nor creates it gratuitously; but an auxiliary fan may occasionally be an advantage in this respect —that it enables the ventilating power to be distributed where it is most needed.

Mr. M. Walton Brown said that the conditions under which the experiments were made were not those ordinarily existing at the colliery, but by making use of the two fans the experiments

were rendered possible. The ventilation was only auxiliary for the purposes of the experiments set forth in his paper.

The Rev. G. M. Capell (Passenham) asked whether the Busty fan was blowing or exhausting.

Mr. M. Walton Brown said that it was exhausting air from the mine and forcing it into the upcast shaft.

Mr. A. Lupton asked whether the Busty fan blew the air through the bank fan.

Mr. M. Walton Brown said that was so, and in some cases ½ inch of pressure was shown on the water-gauge at bank.

Mr. N. R. Griffith said that it might interest those members who did not recollect the fact to remind them that the first suggestion that the ventilation might in some cases be improved by a system of assisting air-currents, in which more air was required, by the use of auxiliary fans placed underground, was made (he thought by Sir Lindsay Wood) at a meeting in London exactly 25 years ago,* and he (Mr. Griffith) discussed the matter with another member, Mr. H. Hall, H.M. Inspector of Mines, and they both agreed that they would like to see the experiment tried. Everything came to the man who waited, and they now found that the experiment had been tried: the results were most interesting, and would perhaps help the members in future, when they had to work larger areas and longer distances, and the ventilation-problem became more difficult to deal with.

Mr. A. Lupton said that when a person came forward to read a paper on fans he deserved their deepest gratitude. Interesting as the experiments were from a scientific point of view, he thought that the airways of the mine were a great deal too large for experiments of this nature, the results obtained with a single fan being almost identical with those obtained with the two fans, so far as the Busty seam was concerned. When the Busty fan was not running, the ventilation was 37,000 cubic feet per minute. When the Busty fan was running at the highest speed at which it could run, the ventilation was only 42,000 feet; or an increase of about one-seventh when running at the highest possible speed. He thought that, if the experiments had been

* *Trans. N.E. Inst.*, 1876, vol. xxv., pages 195-196.

tried at a mine where the bank fan was working with a high water-gauge of 5 or 6 inches, and the ventilation required an auxiliary underground fan nearer the face, also producing a water-gauge of 5 inches, the auxiliary fan would have given a different result; and the higher water-gauges and differences would form a more reliable basis for theoretical deductions. The experiments detailed in Mr. Brown's paper were more in the nature of two main fans ventilating a colliery, under peculiar circumstances of intermediate airways. Of course, it was all the better for Mr. Brown to introduce such an exceedingly complicated problem, and then to apply his mathematical faculties to its elucidation, and this only increased their debt of gratitude to him.

The Rev. G. M. Capell said that, with regard to district ventilation, he thought that he had built one of the earliest fans in that connection, about 11 years previously, at Ryhope colliery, where the coal was worked about 1 mile under the sea. It was an open-running fan, 8 feet in diameter, driven by compressed air, placed behind a division in the airway, so that the fan exhausted and delivered into the airway; and about 45,000 cubic feet of air per minute was pressed through the district, where enhanced ventilation was required. Since that date, he (Mr. Capell) had had much experience in the matter of district ventilation, on account of the large number of his fans used in mines in Germany, Austria, and Hungary, for that purpose. The result of all his experience had been that in very difficult ventilation-problems auxiliary fans could force air into districts where it could not be obtained by the use of the ordinary bank fan, even when running at 7, 8, or 9 inches of water-gauge. The effect of the underground fan on the upper fan would depend on the passing capacity of the upper fan. If they had an upper fan, with a capacity at least 16 or 18 times that of the lower fan (they did not require a very large upper fan when there was a small one below), they would get a more decided advantage, he thought, than had been shown in this particular case, where there was only a difference of less than one-sixth. His experience, which was not quite the same as that of other members, was that taking an ordinary 5 foot fan, running underground, he should think under ordinary circumstances that 30,000 feet of air per minute could be obtained, and an 8 feet fan,

on the surface, would give about 70,000 or 170,000 cubic feet of air per minute, one being a single and the second a double-inlet fan, under similar conditions. The main point appeared to be that, whatever volume of ventilation they had in the mine, the aggregate of the water-gauge of the fan below ground and the fan above ground would come very nearly to what the same effort applied on the surface would bring about. That had been his experience, and it was quite possible to suppose that if they erected a large enough fan in the mine, made that fan draw from one of the longer portions of the mine, and forced the air through the long airways, then the combined effort would produce a considerably larger quantity of air through the mine, by acting, as it were, as a relief force to the friction which was spread over the whole mine. He thought that the deductions which had been made were very useful, and anything that would bring them nearer to accuracy in the matter as to the effect of two fans working in tandem would be most helpful, but at the same time he was bound to say that the conditions which they got would vary vastly with the distance between the fans.

Mr. S. F. WALKER (London) said that he pointed out on the previous day the close connection between electrical laws and those governing the distribution of air by fans, and Mr. M. Walton Brown's experiments further confirmed that view. The fan in the Busty seam was similar to what in electrical work was called a "booster," which was an apparatus to save copper; to make up for the loss as the load was increased. Pressure was added at a particular point to make up for the pressure which was lost owing to the copper being a little smaller than it otherwise should have been. He was also struck with the phenomena mentioned by getting the current reversed. If they had two generators delivering current to the same circuit, with branch circuits taken off the main circuit, in different positions, they might have the current in a particular branch reversed; or, again, the current in that branch might be due to the difference in pressure of the two generators. He found that in work of that kind they would have to follow all the circuits very carefully, if they had generators at different points, to see that they were not getting a back-pressure. A question suggested by electrical work was as to whether synchronism had anything to do with the matter. When they were drawing air out of a

mine, or driving it in as the case might be, the volume was continuous, but it was produced by a succession of impulses: the fan-blades striking very quickly, so that the impulses were successive although exceedingly small. The time between the alternating currents was also exceedingly small, and they found that they produced peculiar conditions. When running two alternators, for instance, one would run the other as a motor, but it was on condition that they ran in synchronism; if not, the other one would stop. Possibly if the impulses of the fan below ground were not at the same instant as the one above ground, they might get some back-pressure, which would produce all sorts of trouble and apparently puzzling phenomena.

The CHAIRMAN (Mr. H. C. Peake) said that the paper came rather as a surprise to him, and he would like to read it over at home before making any remarks. He proposed, however, that a hearty vote of thanks be given to Mr. M. Walton Brown for his trouble in making the experiments and in writing the paper.

The Rev. G. M. CAPELL seconded the vote of thanks, which was very heartily adopted.

Mr. M. WALTON BROWN acknowledged the vote, and said that the main point of the paper was that when the two fans were run at speeds of equal volume-producing power, there was 26 per cent. more air circulated than with either fan running alone; but, with either lower or higher speeds of either fan, the volume did not attain so high an increase.

DISCUSSION ON MR. H. S. GAY'S PAPER ON "A SINGLE-ROOM SYSTEM OF MINING: AN ADAPTATION OF THE LONGWALL METHOD TO WORK IN THICK SEAMS."*

Mr. H. RICHARDSON HEWITT (H.M. Inspector of Mines, Derby) wrote that the writer of the paper had adopted a system of longwall working to a thick coal-seam in West Virginia, and in his description thereof he had mentioned nothing as to the packing of the working-places; as, however, he stated that the roof was self-supporting at a span of 120 feet, it was presumed that no packs

* *Trans. Inst. M. E.*, 1907, vol. xxxiii., page 558; and vol. xxxiv., page 448.

were carried along with the work of removing the coal. Why could he not have started the first range of packs by using some explosive in the roof of the goaf, so as to give the goaf a first breaking edge? If this had been done, and if substantial packs had been built up, allowing fairly large wastes between each pack, it was probable that the wastes would have broken in behind the timber as the work of removing the coal-face proceeded. His description of a seam 5 feet 7 inches thick as being "thick" would scarcely agree with the definition of the term as understood in this country, and his method of using a hundred props, costing £10 each, was certainly very novel. It would be interesting to know how long these props were of any service to him, and how many he lost under falls of roof, as he did not appear to have used them beyond his first experiment.

The longwall system of working without packs was bound to prove a failure wherever practised, and the first consideration before adopting the system was to provide suitable packing material.

In the table of hands employed, a foreman appeared to be required in the entries sending 60 tons per day, but no such person was wanted in a room sending 300 tons per day. Why should this be so?

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

EXCURSION-MEETING,
HELD AT SOUTH BANK, OCTOBER 30TH, 1907.

CARGO FLEET STEEL- AND IRON-WORKS.

The properties of the Cargo Fleet Iron Company, Limited, consist of ironstone-mines at Liverton, in Cleveland, limestone-quarries at Mickleton, in Teesdale, and coke-ovens, bye-product plant, blast-furnaces, steel-furnaces, and rolling-mills at Cargo Fleet, near Middlesbrough.

The Cargo Fleet steel- and iron-works, which were visited by the members, comprise a Humboldt coal-washer, capable of dealing with 60 tons of coal per hour. The coal is taken direct from the washery to a central coal-bunker, situated between two batteries, each of fifty coke-ovens, of the Koppers regenerative type.

Attached to the coke-ovens is a bye-product plant for dealing with the waste-gases, out of which are manufactured tar and sulphate-of-ammonia; and it is in contemplation to add a benzole-plant.

From 40 to 50 per cent. of the gas produced at the coke-ovens is utilized, after being purified, in driving two Premier gas-engines, each of 500 horsepower, for generating electricity: the remainder being used at the steel-works, in the place of producer-gas, for firing mixers.

The coke, when drawn from the ovens, is delivered from an inclined bench into electrically driven coke-cars, which in turn deliver it into small bunkers, whence it is conveyed by travelling-skips or belts into the furnace-hoist skip, being then charged into the blast-furnaces by means of self-tipping furnace-charging appliances.

Between the two batteries of coke-ovens, which are situated immediately behind and parallel with the range of blast-furnaces,

stand two large parabolical bunkers, divided into compartments, for the storage and delivery of the ores and limestone used in the manufacture of pig-iron. A very fine overhead gantry traverses the whole length of the range of bunkers, and large open spaces are provided where stocks of ore can be deposited for future use.

There are two furnaces at present erected, and provision has been made for the erection of others. Those erected are each 90 feet high with 11 feet hearth and 21 feet bosh, and have each an output capacity of about 1,400 tons, when working on Cleveland ironstone. The blast is supplied by seven gas blowing-engines of the Cockerill type, each capable of delivering 14,000 cubic feet of free air per minute, at a pressure of 10 to 12 pounds per square inch. The blast generated is fed into the blast-furnace through a range of Cowper fire-brick stoves, twelve in number, 55 feet high to the springing of the dome.

The gas from the blast-furnaces provides the heating power for the Cowper stoves, and the spare gas, after being washed in Theisen gas-washers, of which there is an installation of three, two of which are capable of dealing with the whole of the gases from the furnaces, amounting to about 1,800 cubic metres per minute, is used firstly for driving the gas blowing-engines; secondly for driving two electric generators, each of 375 kilowatts; and thirdly for generating steam in the boilers driving the rolling-mills.

The company have a very fine electric installation, and supply all the power and lighting required for the works. The plant consists of one compound steam direct-driving set of 350 kilowatts; two steam turbo-generator sets, each of 750 kilowatts; two Premier gas-engine generator sets, each of 300 kilowatts; and two gas-engine generator sets, each of 375 kilowatts, already referred to. The generators all run in parallel on a 220-volt continuous-current circuit, the load being distributed by one large switchboard of six panels.

The metal from the blast-furnaces is taken in a molten condition in large ladles on cars, direct to the steel-furnaces or to the mixers. The steel-smelting plant consists of three Talbot furnaces, each of 175 tons capacity, and another of 250 tons capacity. The metal is there converted into steel by the Talbot continuous process. This process has been well described by Mr.

Benjamin Talbot in a paper* read before the members of the Iron and Steel Institute, and also in subsequent papers which have been read before the same Institute. Briefly, it consists in converting, in a large bath, the molten metal into a proper condition for casting into steel ingots, and withdrawing about one-third of the molten steel, then adding to the remainder of the steel in the bath lime and oxides, forming a highly oxidizing calcareous slag at a high temperature. When in this condition, molten metal is poured into the furnace, either direct from the blast-furnaces or from the mixers. A violent reaction immediately takes place, and the metal in the bath is quickly worked down again into a soft condition. The process is continuous throughout the whole week, and the furnace is only emptied at long intervals for repairs. The steel is run into 50-ton capacity ladles which are then taken by 75-ton overhead cranes, of which there are two, and run into ingot-moulds standing on cars which are moved by a hydraulic pusher. On the cars the ingots are run by a locomotive under the stripper, where the moulds are taken off, and the ingots are hauled forward and taken up by an electric overhead crane and lowered into soaking-pits. From these pits the ingots are again taken by an overhead crane and laid on to a tilting-chair at the end of the cogging-mill live roller-gear.

The cogging-mill is of the most powerful type. It consists of a mill, with rolls 8½ feet wide and 40-inch centres, driven by a three-cylinder compound condensing-engine of 45 inches and 52 inches stroke. The three cylinders are all of the same size, one being high-pressure and two low-pressure; but by the use of valve-gear they can all be operated as high-pressure cylinders.

After the ingots have been cogged down to the required size, they are conveyed by live roller-gear, electrically driven, to the hydraulic bloom-shears, where they are cut into the required lengths and transferred on to a Collins charger, which delivers them into two gas-fired re-heating furnaces preparatory to the finishing process. The same charger withdraws the blooms from the re-heating furnace and delivers them on to the live roller-gear of the finishing mill.

* "The Open-hearth Continuous Steel Process," by Mr. Benjamin Talbot, *The Journal of the Iron and Steel Institute*, 1900, vol. lvii., page 33.

The finishing mill is provided with two travelling tables, one on each side of the rolls, which enables rapid transference from the first pair of rolls to the intermediate and the last.

From the finishing mill the product is carried forward on live roller-gear to the hot saws, where it is sawn to the required lengths and delivered on to the hot banks. The engine for the finishing mill is practically a duplicate of the one for the cogging mill.

The boiler plant consists of one Nesdrum and eight Babcock water-tube boilers, for the electrical plant, and subsidiary steam-engines, and of ten Nesdrum and two Lancashire boilers for the rolling-mills.

There is one central condensing-plant of the Weiss type, capable of dealing with all the steam from three mill-engines, of which two only are installed.

The Company is at present chiefly engaged in the manufacture of shipbuilding sections, joists, and channels and rails. The works are favourably situated at the junction of the old Cleveland railway and the North-eastern Railway Company's Middlesbrough to Saltburn line, with sidings on both railways. The Company owns about 140 acres of foreshore land, which is being utilized for slag tipping, and thereby brought into a condition fit for the erection of any important industrial works. It has direct communication between its works and its own wharf on the river Tees, where vessels of 5,000 tons burden can be loaded or discharged. The depth of water in the berth is 16 feet at low water on spring tides. The works are very fully equipped with every class of machinery for dealing economically and speedily with its products or appliances, and have very large repairing, smith's, and boiler-shops, so making them quite independent of outside engineering establishments.

The raw material for the blast-furnaces is chiefly Cleveland ore, produced at the Company's own mines at Liverton, where they own a royalty over about 2,500 acres.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

STANNIFEROUS AND AURIFEROUS DEPOSITS OF THE TRANSVAAL AND RHODESIA.

Einige Bemerkungen über afrikanische Erzlagerstätten. By R. Beck. *Zeitschrift für praktische Geologie,* 1906, *vol. xiv., pages* 205-209, *with* 2 *figures in the text.*

In the course of his journey through South Africa in 1905, as a guest of the British Association for the Advancement of Science, the author was able to amass a scientifically valuable and interesting collection of rock-specimens. The study of these has formed the main basis of the observations summarized in the present abstract.

The stanniferous deposits of Enkeldoorn in the Buschveldt, north of Pretoria, were discovered in April, 1904. The main lode strikes north-northwestward through the red Buschveldt Granite, which here, however, has lost much of its red coloration, and should rather be described as greyish-green. This porphyritic granite, so well-known for the remarkable micropegmatitic structure of its groundmass, has been shown to send apophyses into a hard splintery greenish-grey felsite, which crops out east of Enkeldoorn Spruit, a relationship which recalls the association in the Saxon Erzgebirge of the Zinnwald Granite with the older Teplitz Quartz-porphyry. On the other hand, a younger fine-grained granite sends apophyses into, and forms bosses amid, the Buschveldt Granite, and it is this younger granite which is the original ore-carrier.

The Vlaklaagte tin-ore deposits, a little way north-east of Enkeldoorn, and about 31 miles north-east of the Premier diamond-mine, show a still closer lithological resemblance with the Zinnwald rock-series. Corresponding to the Teplitz Quartz-porphyry is a felsite which occurs more especially in the western portion of the mining field; it is traversed by the red Buschveldt Granite, just as in the Erzgebirge the Teplitz Porphyry is invaded by the Zinnwald Granite. In both districts, the latest eruptives are fine to medium-grained grey granites. Microscopic investigation shows the complete independence of the younger granites from the older. At Vlaklaagte, as at Zinnwald, quartzose lodes of tin-ore occur in the younger granites, such as the junction-lode, 3¼ feet thick. Parallel with the lodes (again, just as in the Erzgebirge, and also as in Cornwall) run strips of greisen, about a foot wide, extremely rich in tinstone; this greisen, as usual, shows not a trace of the original felspars of the granite, and the author describes the results of a microscopic examination of the rock. A specimen of highly-decomposed Buschveldt Granite from Rooipoort proved to be impregnated with arsenical pyrites as well as granules of cassiterite. The author has also seen, and briefly describes, some very fine specimens of tin-ore from Swaziland.

The most interesting occurrence of gold in Rhodesia, from his point of view, is that of the Ayrshire mine in the Lomagunda district of Mashonaland. Here a hornblende-gneiss is worked containing native gold in the form of inclusions, the other chief mineral constituents being orthoclase, plagioclase, quartz, hornblende, and epidote, and more rarely ilmenite, titanite, biotite, magnetic pyrites, iron pyrites, and graphite. The workings have already been pushed down to a depth of 460 feet; but the proportion of gold, which in the upper levels (with secondary enrichment favoured by weathering) averaged 0·736 ounce per ton, at depths below 160 feet or so, has fallen to a quarter or half-and-ounce per ton. The ore-body has been proved for a length of about 1,500 feet, along the strike, and seems to be conformably intercalated among the steeply northward-dipping crystalline schists. It seems evident that the gold existed *in situ* before the metamorphism of the gneiss took place. In the year 1904, a rich auriferous conglomerate striking parallel with the Ayrshire deposit some 9 miles farther south was discovered, and traced over a length of more than 2¾ miles. The outcrop was in part worked out by the ancient miners. Occasionally magnetite and a little pyrites are found associated with the gold. At the Eldorado mine near the Hunyani river, where the auriferous banket averages 6 feet in thickness, the amount of gold per ton is 0·768 ounce. This rock bears no resemblance whatever to the well-known bankets of the Witwatersrand. The author lays stress on the abundance of carbonaceous particles in some of the gold-reefs of the Rand (as, for instance, in the hanging-wall leader of the Buckshot Reef), and by way of contrast gives a description of the cementing-material of the Tarkwa conglomerate of West Africa. L. L. B.

MINING DEVELOPMENTS IN THE GERMAN COLONIES.

Über geologische Untersuchungen und die Entwickelung des Bergbaues in den deutschen Schutzgebieten. By — SCHMEISSER. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv.*, *pages* 73-81.

Togoland.—A recently-discovered very pure Eocene limestone is being quarried and burnt for lime, which will obviate the necessity of paying such prices as £4 per ton for imported lime. At Toweya, a quartzitic sandstone, seamed with veins of chalcedony and quartz, carries a little gold. In the Banyeli district, a fine deposit of red hæmatite, some 40 feet thick, overlies a series of conglomerates, quartzites, arkoses, and shales with interbanded dolomites, which in their turn are underlain by an ancient ground-moraine of Permo-Carboniferous (?) age, full of striated boulders of foreign rocks. The iron-ore appears to be of metasomatic origin, the result of the action of ferruginous waters on a pre-existing limestone or dolomite. It is estimated that, by opencast working alone, 20,000,000 tons could be got from the principal deposit, and the ore is thought to be of very uniform character. Other deposits are known to occur to the west of that just mentioned. In the Lamatishi mountains an eruptive rock is found, with which are associated great blocks of titaniferous magnetite. In the clay-slates near the village of Kudyambo, inclusions of graphite, alternating with thin layers of quartz, are observed. About 10 miles south-west of Sokode, a metalliferous vein, 4 to 5 inches thick, crops out at a small waterfall on the Kendi; the gangue is chiefly quartz, mineralized with galena, chalcopyrite, and iron pyrites.

Cameroons.—About the end of 1904, mineral oil was struck at several points in the neighbourhood of the coast; but a bore-hole put down at Logobaba

attained the depth of 2,624 feet from the surface, and the younger marine sediments had not then been bottomed, nor had the oil-bearing strata proper been reached. Consequently it is still uncertain whether rich or even workable petroleum-deposits really occur in the colony. Concessions have been granted for mining tin-ores, an apparently rich deposit of these having been found in the Banyo district. Copper-ores are said to occur six days' journey south-east of Lau on the Benué.

German South-West Africa.—The great and rich copper-ore deposit at Otyisongati, near the headwaters of the Swakop, will form the object of active mining operations, so soon as peace has been re-established in that sorely-afflicted colony. Complete investigations as to the extension of the deposit in depth have not been practicable under the circumstances. A Swakopmund company is preparing to work another copper-ore deposit, that of Gorap. Immense deposits of a very beautiful marble occur at Etusis, but there is some question as to whether the tremolite-inclusions which it contains do not interfere sufficiently with its cohesion to prevent it from withstanding all the stresses and strains to which it would be necessarily exposed, if used widely as a building-material. The rebellion has prevented further exploration-work among the supposedly diamantiferous blue ground of the Gibeon district. For similar reasons, the investigations started by the German authorities, as to the water-supply and as to the debatable existence of a coal-field in the colony, cannot be pursued at present.

German East Africa.—Government geologists, primarily occupied in seeking sources of water-supply for the larger settlements and for the main caravan-routes, incidentally recorded the existence of industrially important mineral-deposits. On the Iramba plateau, which is built up in part of granite and in part of crystalline schists, several reefs of auriferous quartz occur, furnishing typical examples of secondary enrichment in the cementation-zone above the underground water-level. Astonishingly rich in gold at and near the outcrop, these reefs become rapidly poorer in depth: thus, samples of quartz and native gold from depths not exceeding 65 feet have yielded assays of 128 ounces or more per ton, while the sulphidic ores from depths of 130 feet or so will perhaps yield barely as many grains. In the Ikoma gold-field, some 60 miles south-east of Speke Bay on the Victoria Nyanza, two islands (as it were) of greenish hornblende-schist rise from amid a sea of gneiss. The easternmost of these is traversed by five parallel reefs of auriferous quartz; while the westernmost can only boast one such reef, but this is said to be of considerable thickness and extent, and may be expected to prove richer in depth than usual. The easterly reefs are from 2 to 3¼ feet thick, of no great extent, and in their general habit recall the Iramba facies. Similar reefs occur at Sargidi, 3 hours' journey by road north of Ikoma, and near Nassa, south-east of the Victoria Nyanza. The Zentral-Afrikanische Bergwerks Aktiengesellschaft has been formed to work the Ikoma reefs, among others. The company has found in the Ussongo district a cavernous, ironshot, auriferous breccia, estimated to yield about 1 ounce troy of gold per ton. With it is associated a quartzitic ferruginous sandstone, cropping out west of the caravan-road, and also containing a small percentage of gold. As to gold-dredging in the rivers or placer-deposits, the prospects do not appear very promising. It must be borne in mind that, generally speaking, the rivers in that region have a short course, and during most of the year carry but little water in them. They are not, therefore, adopted to the formation of alluvia on a considerable scale, with the single exception of the Moamc.

A concession was obtained in 1903 (by a Berlin publisher) for the exclu-

sive working of deposits of precious and semi-precious stones in a district bordering on the middle and lower course of the Rovuma. Here had been found, in an earthy, weathered hornblende-gneiss, inclusions as big as a man's fist of an almandine-garnet rich in magnesia. The garnets occur in great quantity, and are of fine quality; and so they have already found a market. The investigations made as to the possibility or advisability of attempting to work the graphite of Likongo and Nambirambi, do not seem to have eventuated favourably. Mica-deposits occur in various districts, and, although not comparable with the best Indian occurrences of the kind, they are capable of yielding a marketable mica, which may ultimately compete with the North American mineral. The dusky greenish-brown coloration of the East African mica is rather a disadvantage, which militates against its utilization for lamp-chimneys, for example; but the mineral has been shown by experiment to be a better insulator than the American mica, although inferior (in that respect also) to the Indian mica. Radio-active uranium pitchblende was found, in 1904, to occur at an altitude of about 6,500 feet above sea-level, in the form of blocks, on the western slope of Lukvangule mountain, in south-western Uluguru. Common salt is got in the Uwinga district; and in the dry season common soda evaporates out on the shores of a natron-lake near the boundary, in the Moshi district.

Kaiser Wilhelm-Land (New Guinea).—The existence of gold is undoubted in all the rivers that course through the district lying between the eastern boundary and Cape Longuerne. To judge from the finely-divided native gold deposited in the lower reaches of the Varia, that river must be very rich in its upper course, which is, however, in British territory. Investigation has been mainly directed to the Vivo river-alluvia, in the uppermost 3 to 6 feet of which gold occurs in flakes of a very ruddy hue, often filmed over with iron-oxide. The bed-rock, curiously enough, fails to yield any of the precious metal. The gold appears to have been swept out of fissures in the diorite, in the decomposition-products of which rock it occurs in small quantity even up to the summits of the hills, whence the heavy rains carry it down into the valleys. The Vivo placers would well repay working, as their average yield promises to be high in comparison with that of Australian placers; but the climatic conditions are trying. The gold has not been transported very far in any case, and the primary deposit may yet be discovered up in the hills; but, again, several miles of the upper course of the Vivo are within British territory. Native copper of remarkable purity occurs as the infilling of fissures and cavities in the Kabenau basalt. Coal has been found in the Nusa valley, comparable in many respects with a Bochum gas-coal, but yielding a great deal of ash and containing much hygroscopic water. On distillation, it yields 57·5 per cent. of pulverulent coke.

Kiaochau.—Anthracitic coal has been proved on the island of Shui-ling-shan (Tolo-san) within the leased area, but it appears very doubtful whether the deposit will repay working. In the hinterland (which our German friends unquestionably extend to the entire province of Shantung), a German company is now at work in the Weihsien coal-field, near Fangtse, on three coal-seams, the uppermost of which averages 10 feet in thickness, the middle one 13 feet (yielding gas-coal), while the lowermost varies from 3½ to 16 feet or more in thickness. The thickness and quality of the middle seam are affected in places by porphyrite-intrusions. The output for the year 1904 amounted to 84,887 tons, and for the first six months of 1905 it had already reached a total of 69,815 tons. A modern sorting-plant delivers big coal and nuts for the use of the railway and various factories at Tsingtau, while the smalls

and the duff are eagerly purchased by the Chinese. But the washing-plant and briquette-factory now being erected will use up even those residues.

In the Heishan basin, the coal-seams are generally thinner, few exceeding a thickness of 3½ feet, while the thickest of all measures 6 feet. They are divisible into an upper and a lower group, each including two or three workable seams of bituminous coal. Successful bore-holes for coal are proceeding in the Poshan-Chichwan basin.

Magnetites and hæmatites have been proved in several localities, but the most important deposit is that which crops out at the contact between limestone and quartz-augite-diorite at Chi-ling-chen, north of the Poshan valley, on the flanks of the Tieshan. It is from 50 to 65 feet thick, can be followed over a distance of 1¼ miles, and consists of magnetite and red hæmatite with 65 per cent. of iron. Exploration-work is now being conducted on it. In the Ichufu mountains gravels are being washed for diamonds, and the mica-deposits of Chaucheng will repay further attention. Unfavourable reports have been received, however, regarding the plumbiferous deposits of Beishiling. Boring for coal at Tsinkiachung has been temporarily suspended, because the apparatus had reached the limit of its capacity. In the Maushan hills, gold-quartz reefs in granite are being worked with sufficient success. The main reef averages 15¼ feet in thickness, is traceable for more than 3 miles, and yields 185 grains of gold per ton.

The now completed Shantung railway links up the Weihsien, Putsum, and Poshan coal-fields, as also the Chilingchen iron-ore-deposits, with the city of Tsingtau, and industrial developments are proceeding apace.

L. L. B.

URANIUM-ORES FROM GERMAN EAST AFRICA.

Ueber Uranerze aus Deutsch Ostafrika. By W. Marckwald. *Centralblatt für Mineralogie, Geologie und Paläontologie,* 1906, *pages* 761-763.

Certain mica-quarries worked in the western flanks of the Lukvengule, Uruguru mountains, district of Morogoro, have yielded a variety of altered pitchblende, which, on the mica being split up, is found to permeate it in the form of crystals, some of which attain such a size as to be too heavy for one man alone to carry. By a peculiar and intense process of weathering, accompanied with the formation of pseudomorphs, the pitchblende has been altered into a hitherto unknown mineral—uranyl carbonate. Where the weathering has not proceeded far enough to effect complete alteration, the original black mineral is revealed on removal of the yellow crust of carbonate, and proves to be of remarkable purity, containing very nearly 88 per cent. of an oxide of uranium ($U_3 O_8$). Apart from 7¼ per cent. of lead monoxide, the impurities are of little consequence, and the pitchblende possesses a radio-activity exceeding that of the Joachimsthal mineral by 20 per cent. The specific gravity is 8·84. The weathered mineral is nearly pure uranyl carbonate, there being only about 4 per cent. of other constituents in it; its specific gravity is 4·82, and its radio-activity is about the same as that of the pitchblende just described. It is interesting to note, by the way, that the artificial preparation of uranyl carbonate has so far defied the endeavours of the chemists. The name "rutherfordite" is proposed for the new mineral, in honour of Prof. E. Rutherford.

It is not yet certain whether this occurrence of uranium-ores in German East Africa is likely to prove of industrial importance; but, considering the great value that is attached to such ores at the present time, the discovery is worthy of note.

L. L. B.

AURIFEROUS DEPOSITS OF MADAGASCAR.

L'Or à Madagascar. By L. Gascuel. *Annales des Mines,* 1906 *series* 10, *vol. x., pages* 85-108 *and* 1 *plate.*

Among the hopes which prompted the French annexation of Madagascar, was the fond illusion that the island would rank high among the gold-producing regions of the world. True it is that the output of precious metal from Madagascar is at present far from insignificant, but it does not remotely approach the expectations that were formed of it ten years or so ago.

For many generations, prospecting for gold was forbidden under penalty of death by the Hova rulers, but this law was repealed in 1883 by the ex-Queen Ranavalona, and mining operations were conducted as a Government monopoly by means of what was, to all intents and purposes, slave-labour. The system proved so unsuccessful that the Malagasy Prime Minister consented in 1886 to grant mining concessions to Europeans, the Government undertaking to furnish labour or to facilitate the recruiting of labour, in consideration of a fixed percentage of the profits of mining. The results were, however, unsatisfactory, and at the time of the French invasion, knowledge of the auriferous deposits of the island had made no advance, the legendary accounts of the natives remaining the chief substitute for such knowledge. After the capture of Antananarivo, prospecting began with a sort of feverish intensity, but the reports of the engineers who traversed the island in every direction on the behalf of European financial syndicates, were without exception unfavourable. They claimed to have found no lodes, only poor placers of limited extent, inadequate to the support of any enterprise conducted on a fairly large scale.

Nevertheless, the gold-output of the island gradually crept up, and new mining districts were opened out—research which had hitherto been confined to the central and western areas having been in 1899 extended to the eastern forest-belt, the mineral wealth of which brought it rapidly to the fore. In 1897, Madagascar had produced only 2,315 ounces of gold; but in 1904, the annual output rose to 79,089 ounces. In April, 1905, the announcement in the newspapers of the discovery of a real lode, very rich and of considerable extent at Ampasimbe, near Beforona, was the prelude of a "boom" which ended disastrously. The pessimism thus engendered is not, however, entirely justified.

All the gold at present got in Madagascar is derived from recent alluvial deposits, which occupy the bottom and sometimes the flanks of the valleys up to a certain height. A few fragments of older terraces are occasionally found clinging to the hillsides, but they are never of any great extent. Three principal gold-producing districts are recognized, being, in their order of importance:—(1) The eastern forest-belt, extending along the coast from Diego Suarez to Fort Dauphin, the really productive portion of which at present lies between Fénérivo on the north and Mananjary on the south; (2) the country around Miandrivago and Ankavandra on the west, with a southern prolongation towards Midargy and a northern towards Mevatanana; and (3) in the centre, the country lying along each side of a line drawn from Antananarivo to Fianarantsoa. The extreme northern and southern districts of the island, especially the southern, are still all but unknown geologically, and they are very sparsely peopled.

The alluvia consist of rolled pebbles, clays, and sands, differing in colour according to the rocks from which they are derived. The pebbles are mostly quartz, and it is seldom that they exceed a man's fist in size.

Sometimes the auriferous stratum is found at the surface, while in other places it lies buried beneath many feet of barren ground. The placers are so loosely compacted that they need only be worked with a spade, and the occasion for the use of the miner's pick arises but seldom. The gold occurs in the native state, in the form of spangles, flakes, more or less rounded granules, and even in comparatively large nuggets; the part played by finely-divided gold-dust in the output is insignificant. On the other hand, big nuggets are rare: the biggest yet found (so far as the author knows) does not exceed 16 ounces in weight. In the *batea*, there remains at the bottom, with the gold, a black sand consisting of magnetite, tourmaline, and impure rutile, with probably some chrome-iron-ore. This black sand is frequently accompanied by fragments of pyrites and more or less rounded bits of tourmaline and zircon of many colours, of garnet, ruby, sapphire, blue beryl, topaz, etc. Recently some prospectors have found it worth while to sort out these hitherto neglected residues, on the chance of picking up some saleable gems. In some places, granules of metallic tin are found with the gold; but whether they represent the results of an accidental smelting of cassiterite-outcrops during the seasonal grass-fires, or the melting-down during those same fires of the preserve-tins accumulated in camp-rubbish, is still an open question. Considering the abundance of pegmatitic rocks in the island, and considering that cassiterite and granules of tin are known associates of gold in other countries in alluvia very similar to those of Madagascar, the occurrence of stanniferous deposits is, at all events, not improbable.

After explaining how the gold-bearing alluvia at the bottom of certain valleys could be worked over again at a profit after an interval of a few years' rest, the author describes the method of working, which is of the simplest and most primitive description. Natives (men and women) recruited by the European concessionaire from the villages of the Imerina and Betsileo countries, build themselves a sort of mining camp in the neighbourhood of the white man's dwelling, dig the stuff out of the alluvia, and wash it for gold, on the understanding that they sell to him all the metal that they get at a price which is equivalent to about a shilling or 13d. for 10 grains. Mining work begins in the majority of cases in April, after the rains and the rice harvest are over, and in October, towards the close of the dry season, most of the natives leave the mining camps to go back to their paddy-fields. Ground-sluicing is well understood and practised, and the Malagasy (thanks to the experience gained in cultivating a plant needing so much irrigation as rice) show a quite remarkable aptitude in constructing canals for bringing water to the gold-washeries when needed. Nevertheless, the method of working is sufficiently wasteful; for instance, good auriferous strata remain hidden away under carelessly heaped-up piles of barren ground or "cover" dug out of another portion of the placer. Moreover, some of the poorer gold-bearing strata are left untouched, because the natives could not earn therefrom, on the present system, a sufficient living wage. At some future time, such deposits may well repay working on a large scale. In fact, the author holds that, so far, the auriferous deposits of Madagascar have been merely skimmed, not thoroughly worked; and it is on thorough and economically-devised working that the future prosperity of the gold-mining industry in the island will depend. The abundance of water-power everywhere available is an important factor in this respect.

Quartz is of most extraordinarily frequent occurrence in Madagascar—hills are covered with it; it builds up whole ranges of mountains, and some of it is quite conceivably auriferous. In fact, extensive outcrops of solid rock

containing gold, but of extremely unequal tenour, are known to occur, especially in the Central districts. They will prove undoubtedly workable, with the help of cheap labour and cheap motive power. What is now needed is careful study of the local conditions of each of these outcrops. Lodes apparently they are not, but rather huge lenticles of quartz intercalated among the schists which rest upon the basement-granites. This is traversed by numerous dykes of pegmatite, which have, moreover, metamorphosed grits, limestones, and shales into quartzites, marbles, mica-schists, and gneisses, etc. At a later date, all the rocks were more or less infiltrated by silicifying solutions carrying gold and sulphur. There are some thin and discontinuous, locally rich lodes, where the granite itself has been laid bare; but these are not likely to prove industrially important. Still, there are some few localities where it may be found possible to work even these lodes at a profit. The extreme variability of the auriferous quartz of Madagascar in aspect, colour, texture, etc., is very puzzling for the prospector; but the author is confident that a patient resolve to overcome this and other difficulties will, in the long run, be amply repaid. L. L. B.

RARE MINERALS FROM MANICALAND, SOUTH AFRICA.

Sur quelques Minéraux Rares des Mines Aurifères du Manicaland. By J. Couyat. *Bulletin du Muséum d'Histoire Naturelle*, 1906, *No.* 1, *pages* 74-76.

The district of Mozambique, recently explored by an emissary of the French Government, occupies a parallelogram extending some 22 miles from east to west and some 14 miles from north to south, near the borders of Rhodesia. The Revué and its numerous tributaries which water this district come down from a granitic massif the altitude of which varies between 2,000 and 6,000 feet above sea-level, and the centre of the basin appears to consist chiefly of metamorphic quartzites and mica-schists, seamed by a multitude of veins of auriferous quartz. These quartz-veins, and also the gold-bearing alluvia, are worked at no less than two hundred and fifty different localities, whence it may be inferred that gold is extremely abundant within this comparatively restricted area. The assays vary from 1¼ pennyweights to 30 ounces per ton of crude material. The kaolin got from the Zambuzi, Revué, and other rivers, contains as much as 2 pennyweights per ton, but the richest localities are where the quartz-veins contain from 6 to 7 ounces per ton. This auriferous quartz differs in aspect: that of the northernmost belt, upstream from the Shimezi confluence, is mostly hyaline; the quartz of the central and richest belt, between the Shimezi and the Revué, is bluish-grey; and that of the southernmost, between the Zambuzi and the Menenir, is either amethystine, or white encrusted with hæmatite.

The customary associates of the gold in this area are galena, argyrite, stibine, and cerussite; and the various compounds of iron, such as pyrites, marcasite, mispickel, magnetite, hæmatite, and siderite, abound—some being intercrystallized with the quartz, others impregnating the sedimentary deposits. On the Edmundian reef, a chalcopyrite containing 32 per cent. of metallic copper is actively worked.

Among the samples of quartz examined by the author, many were covered with tiny crystals, the outcome of the decomposition of sulphidic compounds of lead and of the formation of chlorarseniates, chlorovanadates, and molybdates (mimetite, vanadinite, and wulfenite). The hexagonal green crystals of mimetite, well-developed little prisms of uniform height, recall the mimetite

of Cornwall and Johanngeorgenstadt. The brown or orange-coloured prisms of vanadinite are of unequal length, and generally resemble the Arizona mineral; and so do the rare, tabular, orange-coloured crystals of wulfenite recall the wulfenite of Arizona.

The Zambuzi schists are traversed by veins, occasionally exceeding 4 inches in breadth, of a fine greenish talc, in large laminæ, like that of the Tyrol. Actinolite and asbestos also occur; and the samples of tourmaline are probably derived from the granulitic veins of Andrada, or from those which cut across the bed of the Zambuzi.

The alluvia are all more or less gold-bearing, and have been the object of mining operations since remote ages—as witness the innumerable shallow pits ranged along the valleys over a breadth of more than half a mile, and so close one to the other that there must have been only just room for a miner to pass in between. L. L. B.

NATIVE COPPER IN BRAZILIAN DIABASES.

Ueber das Vorkommen von gediegen Kupfer in den Diabasen von São Paulo. By E. HUSSAK. *Centralblatt für Mineralogie, Geologie und Paläontologie,* 1906, *pages* 333-335, *with* 1 *figure in the text.*

Diabasic rocks are of widespread distribution in the northern and northwestern portions of the State of São Paulo, in the form chiefly of sills, but not infrequently in that of dykes and bosses, intruded among the sandstones, shales, etc., of the Permian system. The lateritic weathering of the sills furnishes the red earth beloved of the coffee-planter. The building of several new lines of railway has opened up several fresh exposures of diabase; and, in one case especially, near Botucatù, district of Sorocabana, the chalcedony which fills the amygdaloidal cavities in the rock is encrusted with a black hydrated silicate of iron. Between this black crust and the chalcedony are found thin, irregular, highly lustrous flakes of native copper, unaccompanied by sulphides or carbonates of the metal. It is noteworthy that the flakes of copper are invariably surrounded on all sides by the above-mentioned black crust. Although a chemical analysis of the diabase itself fails to reveal any trace of copper, the author is of opinion that the metallic flakes are derived from the decomposition of copper-pyrites previously dispersed throughout the rock in a state of fine division. It is not found now in the hand-specimens, but its leaching-out has given rise to limonite, hydrated silicate of iron, and native copper. The occurrence of minute pyritic granules, irregularly distributed within the basic eruptive rocks of Brazil, has long been recorded.

A similar occurrence of native copper in the coarser-grained, non-amygdaloidal diabase of the Fazenda Serodio, near São Simão, is also described. Here the flakes of native copper are bestrewn amid a black crust, identical with that already mentioned, on the walls of narrow clefts and fissures. Chalcedony and zeolites are conspicuous by their absence. The origin of the native copper is thought to be the same as that assigned to the previous instance.

In the southern states of Brazil, as, for example, near Guarapuava in Paranà, native copper occurs in quartz-chalcedony geodes, in association with a green earthy crust of silicate of iron. But there it is somewhat more abundant, sufficiently so indeed to warrant an attempt at mining it, and a concession for that purpose has already been granted. L. L. B.

DIAMANTIFEROUS DEPOSITS IN BRAZIL.

Über die Diamantlager im Westen des Staaten Minas Geraes und der angrenzenden Staaten São Paulo und Goyaz, Brasilien. By Dr. E. Hussak. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 318-333, *with* 5 *figures in the text.*

The deposits described by the author appear to him to have an especial interest for two reasons: (1) although they are sedimentary deposits, they differ in constitution and in the mineral associates of the diamond from the placers of Diamantinas and Bahia; and (2) they show a certain amount of resemblance with the Kimberley formations. The district with which he deals lies somewhat away from Diamantinas, in the extreme west of the State of Minas Geraes, in the so-called "Mining Triangle," which includes a portion of the States of São Paulo and Goyaz. But diamonds have been found farther afield, southward as far as Franca and northward as far as Catalão. A big diamond weighing 600 carats, as some aver, was discovered recently in the Rio Verissimo (Goyaz), but was smashed up owing to the sheer ignorance of the workpeople. Generally speaking, the rocks of the district are made up of steeply-inclined crystalline schists, with which are associated metamorphosed basic eruptives (diabases and gabbros), unconformably overlain by tough unfossiliferous red sandstones, said to be of Triassic age (the Botucatù grits). Among these are intercalated sills and dykes of an aphonitic diabase poor in olivine. In the southern part of the State of Goyaz, the Triassic sandstones are, however, wanting, and the barelaid crystalline schists form *mesas* some 3,000 feet high. But, of whatever rocks the smooth-worn *mesas*, a characteristic feature of the landscape of the region, may consist, they are generally mantled by *canga* or *gorgulho* (gravels and sands), intermingled with fragments of quartz and more recently-formed limonite and pyrolusite, rounded nodules of diabase, etc., some 6 to 10 feet thick. The author holds that this *canga* is not so much an alluvial deposit, as the outcome of the weathering of the solid rocks by the agencies of a dry tropical climate. He draws attention to the analogies which undoubtedly exist between the diamantiferous regions of Brazil and those of South Africa.

The first district to be described is that of Franca, and here the characteristic feature is the extreme divergence of the mineral-associates of the diamond from those observed in Diamantinas: they include, besides quartz, predominantly tourmalines, gorceixite (phosphatic), *favas* (beans), pebbles of titanium-ore, and a few gems, such as sapphire, chrysoberyl, zircon, etc. Then the tuff-like rocks of Uberabá, rich in perowskite, are described, and it is shown that they originate from a deep-seated rock resembling iolite-jacupirangite, in other words, an eruptive pyroxenite. These tuff-like Uberabá rocks are certainly comparable with kimberlite, although they are much poorer in olivine, and richer in garnet, pyroxene and titaniferous magnetite; in structure the contrast between the two varieties of rock is very marked. North of Uberabá, towards the frontier of the State of Goyaz, are a series of rivers which have long been known to carry diamonds, and the gravels and sands have recently been washed with success; the *favas*, or beans of titanium oxide, being regarded as good indicators of the presence of the gems. A description is given of the old Agua Suja mine; and the author, remarking by the way that operations have recently been resumed in that concession, points out the desirability of putting down borings (if only to a depth of 150 or 160 feet) on the *mesa*, in order to ascertain whether the sedimentary deposits (which carry the diamonds) are everywhere of the same composition and the same thickness.

It is again observed how different are the mineral-associates of the diamond, in this district also, from those which are characteristic of the Diamantinas deposits. Rich finds have been recently recorded from the fluviatile sands of the Rio Verissimo, as above stated; here, and along the Rio Douradinhos, the number of big stones, generally fragmentary and not of the purest water, contrasts with the usually small stones of Agua Suja, etc.

The author describes the titaniferous magnetite-deposit, which he discovered in 1893, some 12 miles east of Catalão, and then refers briefly to the diamantiferous sands of the Rio Claro.

Discussing at some length the genetic relationship between the sedimentary and tuff-like deposits and the eruptive rocks of the diamantiferous region of the "mining triangle," he arrives finally at the conclusion that the question as to what was the original matrix of the Brazilian diamond still remains unanswered. L. L. B.

PALLADIUM AND PLATINUM IN BRAZIL.

Über das Vorkommen von Palladium und Platin in Brasilien. By DR. EUGEN HUSSAK. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 284-293, *with 5 figures in the text.*

The author states at the outset that this paper is to be regarded as supplementary to that published by him in 1904,* the more so that in 1905, owing to friendly assistance from various quarters, he was able to carry still further his investigations into the occurrence of palladium and platinum in Brazil.

In assaying the platinum-ores, he found that it was impracticable, in view of the comparatively small quantity of material available for the purpose, to determine the proportion present of the rare elements, osmium, rhodium, and ruthenium; but, on the other hand, tests were always made for gold, silver, copper, and lead.

The platinum-sands from Nizhni Turinsk and other Russian localities, in which that metal is proved to have been derived from peridotites rich in chromite, show remarkable resemblances with the sands from the Rio Abaete and its tributaries in the State of Minas Geraes, Brazil; and the author claims, as an observation new to science in respect of the platinum from these widely separated regions, that it exhibits microscopic intergrowth with osmiridium. An analysis of the Rio-Abaete mineral shows it to contain 82·81 per cent. of metallic platinum, 9·62 of iron, with traces of palladium and copper, and 7·57 per cent. of insoluble residue (? mostly osmiridium). In the sands of that river, diamonds and a small amount of gold occur for a long distance upstream; but the sands of certain tributaries are said to be far richer in platinum than those of the Abaete itself, which would hardly repay the cost of dredging and concentration. Certain pebbles called *favas* (or beans) of a compact, brown, jasper-like mineral are very common constituents of these alluvia (as also in association with the diamonds at Diamantina and Borgagem), and this mineral turns out to be a new species (named and described in 1906 as gorceixite), a hydrophosphate of aluminium and barium. Some of the *favas* which incline in colour towards dark red, also contain strontium. Detailed descriptions are given of a chromite-bearing olivine-rock, a picrite-porphyry, and an amygdaloidal olivineless basalt, which all occur in the Abaete region. The first-named recalls irresistibly the primary matrix of

* Vol. cxiii. of the *Sitzungsberichte*, of the Imperial Academy of Sciences in Vienna.

the platinum of Nizhni Tagilsk in the Urals; the second is extraordinarily rich in perowskite, one of the constituents of the insoluble residue from the Abaete platinum; and the groundmass of the third is built up of augite, magnetite, and perowskite. A magmatic relationship between these three rocks is inferred.

In form, chemical composition, and mode of occurrence, the platinum mineral found on the eastern flank of the Serra do Espinhaço, between Conceição and Serro, differs entirely from the Abaete platinum. It appears to be in its primary deposit, to have no genetic connexion whatever with olivine-rocks, but to be derived from the Palæozoic (?) conglomeratic sandstones (or from the quartz-veins by which they are seamed) unconformably overlying the crystalline schists (or phyllites and quartzites of the Itabirite Series). Similarly, the platinum of Condado near Serro, exempt as it is from all signs of erosion through transport, appears to have been formed *in situ*, probably by decomposition of pyritic minerals occurring in the above-mentioned sandstone or its quartz-veins. This Condado platinum occurs in the sands of a stream which takes its source among the conglomeratic sandstones, and is associated with diamonds, rutile, anatase, xenotime, etc. Downstream, where the products of erosion of the crystalline schists come in, high-grade gold and palladium-gold make their appearance in conjunction with the platinum. Analysis yields the following results, which are in marked contrast with the assays of the Abaete platinum:—Metallic platinum, 73 to 74 per cent.; palladium, 21·82 to 21·77; iridium, 0·88 to 0·08; iron, 0·10 to trace; insoluble residue, 0·42 to 0·92 per cent. While the one may be termed a palladium-platinum, the other is distinctly an iron-platinum (see the first analysis above). The Condado occurrence is one of the oldest known in Brazil.

Finally, the author describes the platinum of the Corrego das Loges, near Conceição, a tributary of the Rio Santo Antonio. Angular bits of quartz are intergrown with the metal, and their presence is one of the circumstances which lead to the conclusion that this platinum, like the Condado mineral, is a precipitate from solutions, is (in short) of secondary origin. The primary matrix was the micaceous quartzite of the district, or the tourmaline-bearing quartz-veins which traverse that rock. On analysis, the platinum yields rather more than 83 per cent. of the pure metal, with sometimes as much as 3·6 of iridium and 3·64 of palladium. On the whole, none of the platiniferous deposits of Brazil are likely to repay working. The concluding section of the paper is devoted to the description of the occurrence of palladium-gold, especially at Candonga. L. L. B.

TOURMALINE-BEARING COBALT-DEPOSITS IN CHILE.

Turmalinführende Kobalterzgänge. *By* O. Stutzer. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 294-298, *with* 4 *figures in the text.*

The first really detailed notice of the occurrence of tourmaline in metalliferous lodes is said by the author to date from Dr. von Groddeck's paper of 1887 on the tourmaline-bearing cupriferous ores of Tamaya, wherein these were asserted to be unique of their kind. In 1897, Dr. Stelzner, dealing with similar occurrences in other cupriferous ores of Chile, arrived independently at the same conclusions as the first-mentioned writer, and now specimens of tourmaline-bearing cobalt-ores are forthcoming from the Blanca mine at San Juan, department of Freïrina, in the province of Atacama. It may be mentioned, by the way, that specimens of cobalt-ore from the Vallenar mines (in the neighbouring district) were found to be destitute of tourmaline. The San Juan ores occur in quartz-lodes traversing mica-schists; and the

sole primary ore present is cobalt-glance, distinguishable from cobaltiferous arsenical pyrites by the extraordinarily small proportion of iron which it contains, and also by its crystalline habit (small cubical, octahedral, and pentagonal-dodecahedral crystals). It is distinguishable again from smaltine by its fissility, and its unmistakably sulphurous odour and tendency to film over with sulphur when tested by the blowpipe. The secondary ores include cobalt-bloom (erythrite), and cobaltiferous manganese-ore.

The tourmaline occurs:—(1) In the form of a black, extremely porous mass, speckled with brick-red spots of cuprite. Under the microscope, the sole transparent mineral-constituent is seen to consist of small green prisms of tourmaline. This black stuff is got from the superficial portion of the outcrop, and must have originally been the actual gossan of the lode, the tourmaline now alone surviving, thanks to its exceptional ability to resist the various agents of weathering. (2) In the form of a fine-grained black mass, impregnated with dull, bluish-black, cobaltiferous manganese-ore. This material is also extremely porous, all other constituents but the tourmaline, the above-mentioned ore, and a mere trace of quartz, having been leached out of it. The absence of cobalt-glance, the deeper-lying primary ore, is a sufficient indication that this specimen also comes from the upper portion of the lode, the cobaltiferous manganese-ore representing a decomposition-product of the cobalt-glance. (3) In the form of radiating crystals within a rich black merchantable ore, from a somewhat lower level, which is visibly intermixed with quartz and erythrite. Here again, the porous structure of the ore and the absence of cobalt-glance indicate that we are still dealing with portions of the lode that are accessible to weathering agencies. (4) Included within lustrous cobalt-glance, and also crystallized around it. This last specimen forms a tough compact rock, consisting, besides the two minerals already mentioned, of white quartz and erythrite. The microscopic evidence shows that the tourmaline must have originated contemporaneously with the cobalt-glance, although in part it crystallized later than that ore.

The presence of traces of cuprite and malachite in the cobaltiferous specimens suggests a passage into the tourmaline-bearing cupriferous ores now known to be fairly common in Chile. The paper concludes with a *conspectus* of all the metalliferous deposits hitherto recorded as containing tourmaline, including stanniferous deposits, cupriferous deposits, pyritic, arsenical and cupriferous gold-quartz, and ferruginous deposits. L. L. B.

COAL- AND LIGNITE-FIELDS OF THE ROCKY MOUNTAINS.

Les Bassins lignitifères et houillers des Montagnes Rocheuses. By ÉTIENNE A. RITTER. *Annales des Mines, series* 10, 1906, *vol. x., pages* 5-84, *and* 4 *plates.*

The coals of the Rocky Mountains, exhibiting all the gradations from lignite to anthracite, are mostly assignable, as regards age, to the Laramie or Cretaceo-Tertiary group. The basins in which they occur form a discontinuous belt, which can be followed right up the North American continent, from the North of Mexico, through the Western States and British Columbia, into the frozen regions of Alaska. On the Pacific coast there are, moreover, some coal-basins of small extent, of Eocene and Oligocene age. Largely worked as they are already, the coal-basins of the Rockies hardly produce a quarter of their possible output, and industrial activity in those regions is progressing at such a pace that the demand for coal outruns the present supply. The want of available labour is much felt in this respect.

The author appends maps which give a general view of the situation of these coal-basins: they cover an area of 42,500 square miles, while to the east, in the States of North Dakota and South Dakota, is a double lignite-basin extending over 54,000 square miles. He plots out on his map some forty separate basins: but, what are now worked as two separate basins, were often originally deposits laid down in a single lagoon, and later orogenic movements have plicated the deposits and thrust up between them a lofty mountain-range. In sketching the tectonic history of the coal-fields, the author points out that the Rocky Mountains, far from constituting a series of parallel anticlines and synclines, are built up of a suite of monoclinal folds or of anticlinal domes emerging from a horizontal plain. Consequently, the coal-fields, instead of lying in the midst of a synclinal basin, usually form part of a monoclinal limb, or else rim round some anticlinal dome. The Laramie stage corresponds to a geographical change marked by the recession of the sea; along the embryo range of the Rockies, semi-marine and semi-lacustrine deposits were laid down in bays and lakes. In lagoons not entirely open to the sea, vegetation decomposed practically *in situ*, and there is no question here of coal-seams formed by driftwood. Perhaps the more recent date of deposition of the coal will serve to explain how it has failed to undergo quite the same amount of metamorphism as the Carboniferous or true Coal-measure coals of Pennsylvania, Great Britain, France, or Belgium.

As to the anthracite of the Rocky Mountain region, the author connects it with the presence of eruptive rocks, and the rapid local action of volcanoes, of obviously later date than the deposition of the coal. But the metamorphism thus induced is narrowly localized, and one and the same seam within a single basin may show all the gradations from a semi-lignitic coal, through bituminous coal and anthracite, to the natural coke in immediate contact with the eruptive rock. In some few cases, there is a passage without any intermediary from lignitic coal into coke. The distance between an intrusive dyke or a laccolite and the anthracite ranges from 6½ to 65 feet at most; beyond this distance, often for many thousand feet, comes a bituminous coking coal; beyond that again is a coal poorer in carbon, but in every way suitable for firing boilers and furnaces. Immense lava-flows overlie much of the Trinidad-Raton coal-basin, for instance, without having affected the deep-lying coal-seams: in order to metamorphose these, the eruptive magma must either burst through them, or thrust itself into the neighbouring strata; whence it may be inferred that vulcanicity has acted rather through such instruments as superheated steam and the gases accompanying eruption, than through the direct agency of heat.

A vast number of analyses are tabulated, very many being derived from American and Canadian publications. A high percentage of water is characteristic of those Rocky Mountain coals that have best retained their original lignitic nature. These lignites are very susceptible to atmospheric agencies, crumbling away if they are carried for any considerable distance on the railroad, or if they are stacked for many months in a storage-depôt. In considering the quality of various coals, especially when comparing them with the true Coal-measure coals of Europe, the analyst is apt to forget the importance of specific gravity, and the author laments the almost entire absence of such data in regard to these American coals. He notes that those basins that yield the best results for coke in the analyses, and in fact produce the best quality of coal, have usually thinner seams than the basins where the lignitic taint yet sticks to the mineral. It seems fairly evident that, in losing some of their water and their gaseous constituents, the seams have proportionately

diminished in thickness. In comparison with the true Coal-measure seams of Pennsylvania and France, the Rocky Mountain seams exhibit more rapid variations in thickness, number, physical and chemical properties, and other characters.

The second chapter entitled "Geographical Description of the various Lignite and Coal-basins," deals in succession with those of British Columbia, Montana, Wyoming, Colorado, Utah, Idaho, New Mexico, and Coahuila. Turning then to the Pacific coast, the author describes briefly the coal- and lignite-fields of the Alaskan seaboard, Vancouver and Queen Charlotte Islands, the States of Washington, Oregon, and California.

The third chapter deals with the methods of working the mines, and the fourth is taken up with statistics of output, etc., wherein comparisons are drawn with the corresponding statistics from the various coal-fields of France. The output from the Rocky Mountain coal-basins within the last fifteen years has increased by 282 per cent., as compared with an increase of something over 50 per cent. in France. Although the annual working-days of the French miner exceed in number by 1 to 10 per cent. those of the Rocky Mountain miner, the latter sends to the surface daily 30 to 35 per cent. more coal than his European fellow-pitman. It should be borne in mind, however, that in most cases, once the seam has been worked out, the roof is allowed to cave in by the Rocky Mountain miner, as the concessionaires are owners of the surface as well as the subsoil, and the land is generally of small value. In France, labour and time must needs be spent in taking precautions to avoid caving-in of the roof. The author considers that coal-cutting machines have been introduced into the Rocky Mountain mines somewhat haphazard; instead of conducting a thorough preliminary investigation as to the suitability or otherwise of the machines, those responsible have simply left it to practice to determine whether coal-cutting machines were urgently needed or not. Only in Wyoming have these machines been uniformly successful, and there the seams are thick and lie all but horizontal.

It so happens that the coal-fields that form the subject of this memoir include a vast area of the United States, which is destined to absorb within the next twenty years the westward-setting tide of immigration, an area where all the newest railway-lines of the Union are under construction or survey, and where great irrigation-reservoirs are heralding the triumphant march of agriculture into a land that was formerly desert. A brilliant future seems, therefore, assured for the coal-mining industry of the Rocky Mountains.

L. L. B.

PRECIOUS CHRYSOLITE OF ST. JOHN'S ISLAND, RED SEA.

Sur le Gisement de Chrysolite de l'Île Saint-Jean (Mer Rouge). By L. MICHEL. *Bulletin de la Société française de Minéralogie*, 1906, *vol. xxix., pages* 360-361.

A few years ago, a deposit of precious chrysolite was discovered on this island, yielding large crystals of the gem, of a colour, brilliancy, and transparency comparable with the similar characteristics of the Brazilian chrysolite. The deposit is, therefore, of industrial value. The chrysolite-crystals are disseminated in a gangue which essentially consists of serpentine, magnetite and gymnite (deweylite). This gangue is seamed by fissures which are encrusted with rather peculiar fusiform crystals. Under the microscope these prove to be made up of a "skeleton" of quartz clothed with a beautiful green mammillated mineral, the chemical composition of which exactly corresponds with that of the hydrocarbonate of nickel, texasite ($H_{12}Ni_3CO_{11}$). Now, texasite has, so far, been found in very few localities indeed; and both it and

the above-mentioned gangue represent, at all events in part, the alteration-products of a nickeliferous peridotite. L. L. B.

IDENTIFICATION OF COPIAPITE WITH JÁNOSITE.

Nochmals Copiapit und Jánosit. By E. WEINSCHENK. *Földtani Közlöny,* **1906,** *vol. xxxvi., pages* **359-366.**

In this somewhat controversial paper, the author first of all points out that the name "copiapite" cannot be used to define a whole group of natural sulphates of iron, but is applicable, like all other mineral specific names, to one of them alone, which has distinct chemical and physical characteristics.

He then describes in detail the optical and crystallographic identity between the so-called jánosite and copiapite; in a previous memoir he had already shown that they had the same index of refraction and the same pleochroism. The jánosite appears to have been obtained only in fine scales, and therefore differences of specific gravity do not count for much; nor, considering that the material analysed by the discoverer was admittedly impure, do differences in chemical composition carry great weight. However, the author isolated some perfectly pure jánosite from the material sent to him by Dr. H. Böckh, and found that, in specific gravity and in percentage of iron, it coincided exactly with copiapite, in contradistinction to the results obtained by Dr. Böckh. The true formula of copiapite is $2\,Fe_2O_3\,5\,SO_3 + 18\,H_2O$; and, in contrast with the closely-allied minerals, coquimbite and quenstedtite, which are only found in rainless desertic regions, copiapite is perhaps one of the most widespread products of the oxidation of sulphidic iron-ores.

The conclusion is that jánosite must be eliminated from the catalogue of mineral-species. L. L. B.

SULPHATE-OF-IRON MINERALS: COQUIMBITE, COPIAPITE, AND RÖMERITE.

Beiträge zur Kenntniss der chemischen Constitution und der Genese der natürlichen Eisensulfate. VI. By R. SCHARIZER. *Zeitschrift für Krystallographie und Mineralogie,* **1907,** *vol. xliii., pages* **113-129,** *with* **2** *figures in the text.*

The author first of all describes his repeated and finally successful endeavours to reproduce artificially the ferrous-sulphate mineral coquimbite, which led him to the conclusion that this mineral can only be generated from a solution containing an excess of sulphuric acid, over and above the amount of such acid necessary for the formation of normal ferrous sulphate. Or, in other words, coquimbite, associated with acid ferrous sulphate, only arises from solutions wherein the quotient of the molecular ratio, $SO_3 : Fe_2O_3$, is greater than 3 and less than 4.

Experiments with aqueous solutions of römerite proved that, from a solution containing ferric oxide and sulphuric acid in the molecular proportion, 1:3, it is not normal ferrous suphate that will crystallize out, but a mixture consisting of the mineral copiapite and acid ferrous sulphate, a result expressed by the chemical equation: $3\,Fe_2S_3O_{12} = Fe_2S_4O_{15} + Fe_4S_5O_{21}$.

Römerite can only be formed when acid ferrous sulphate and ferric sulphate re-act one upon the other in the presence of minute quantities of water. On mere exposure to a damp atmosphere, römerite splits up into its components; whereupon ferric sulphate (on account of its lesser solubility) partly separates out as a solid; a small portion thereof, together with the ferrous sulphate, going into solution. L. L. B.

FRIGIDITE, A VARIETY OF TETRAHEDRITE.

Tetraedrite del Frigido (varietà Frigidite) e Minerali che l'accompagnano. By ERNESTO MANASSE. *Atti della Società toscana di Scienze Naturali*, 1906, *Memorie, vol. xxii., pages* 81-93, *with* 3 *figures in the text.*

The old Frigido mine, at one time worked for its copper-ores, especially chalcopyrite, but now abandoned for several years, is about ¾ mile distant from the town of Massa, in Tuscany, by the road that runs to Il Forno and La Tambura. The adits, lying very close together, are opened up in both flanks of the small valley through which courses the Frigido torrent, in rocks identical with those among which, at Seravezza, only a little distance off, occurs the Bottino silver-lead lode. They are tourmaline-bearing mica-schists of Permian age, of extremely variable texture and coloration. Among the metalliferous ores found in the ferruginous quartz-veins that traverse these rocks are chalcopyrite (extremely abundant), pyrrhotine, tetrahedrite, pyrite, marcasite, galena, blende, etc., specimens of which are represented in the Tuscan mineralogical collection in the Pisa Museum. The author examined this collection, besides obtaining specimens *in situ* on the occasion of a recent visit to the abandoned mine.

The nickeliferous variety of tetrahedrite, to which the name of "frigidite" was originally applied by the late Prof. A. d'Achiardi, occurs in generally compact masses of a dark steel-grey colour. Its hardness corresponds to 4 in the recognized scale, and its specific gravity varies between 4·7 and 4·8. It melts easily before the blowpipe, giving rise to white antimonial fumes. Insoluble in hydrochloric acid, it is attacked by nitric acid, leaving a residue of sulphur and metantimonic acid; while it is completely soluble in *aqua regia*. Such rare crystals of the mineral as occur show the tetrahedral habit. Complete qualitative analyses of portions of three specimens revealed the presence therein of sulphur, antimony, arsenic, lead, copper, tin, iron, zinc, and nickel. Thereafter the author proceeded to make quantitative analyses of material from the same specimens; and, after trying other methods which proved unsatisfactory, he used *aqua regia* at first in the cold, and then warm (but always much below a temperature of 212° Fahr.). The percentages yielded by these analyses ranged as follows:—Lead, from trace to 0·26 per cent.; copper, from 30·04 per cent. to 37·54 per cent; tin, traces only; iron, from 6·01 per cent. to 9·83 per cent.; zinc, from 0·59 per cent. to 1·98 per cent.; nickel, from 0·14 per cent. to 3·46 per cent.; antimony, from 28·82 per cent. to 29·54 per cent.; arsenic, trace to 1·50 per cent.; sulphur, from 24·48 per cent. to 25·70 per cent. From these results, the author deduces for the mineral, either the general formula: $3\,Cu_2\,S.\,R'''_2\,S_3 + \frac{1}{2}\,(6\,R''S.\,R''_2\,S_3)$; in which R″ represents Sb + As and R‴ represents iron and nickel in the ratio of 4:2; or the formula: $3\,Cu_2\,S.Sb_2\,S_3 + \frac{1}{4}\,(6\,R''S.\,Sb_2\,S_3)$; wherein R″ represents iron and zinc in the proportion of 5:1, nickel being left out of account because of its small percentage in the specimens upon which the second formula is based. Despite the great variability, however, in the proportion of nickel from specimen to specimen, frigidite is properly defined as a nickeliferous variety of panabase. Although cobaltiferous varieties of tetrahedrite are fairly common, nickeliferous varieties are exceedingly rare, especially containing such quantities of nickel as occasionally occur in frigidite. Besides this mineral, the author describes the siderite, pyrrhotine, chalcopyrite, quartz, etc., which are associated with it at Frigido. L. L. B.

OCCURRENCE OF KIMBERLITE IN FISSURE-VEINS, ETC.

Über das Vorkommen von Kimberlit in Gängen und Vulkan-Embryonen. By F. W. VOIT. *Zeitschrift für praktische Geologie,* 1906, *vol. xiv., pages* 382-384.

The great activity of diamond-prospectors in South Africa of late years has thrown much new light on the occurrence of kimberlite. It has been shown that the blue and yellow ground, far from being of restricted occurrence, is to be found all over South Africa in fissure-veins and pipes, from Central and Northern Cape Colony to Griqualand West, from Damaraland to Rhodesia, and northward from the Zambesi into British East Africa, without speaking of the Bloemhof and Pretoria districts in the Transvaal and the Orange River Colony: in fact, throughout the western ranges of the Drakensbergen, there is hardly a locality where the precious diamantiferous breccia has not been found; and now we hear of similar finds in Kentucky on the one hand, and in New South Wales on the other.

The author thinks that great economic importance may ultimately attach to the practice now adopted by South African diamond-prospectors of following up fissure-veins that show a good outcrop, until they come upon the diamantiferous deposit, basing themselves herein on the generally admitted fact that "the pipes all lie upon fissure-veins."

The kimberlite in the veins differs from that in the pipes structurally, but not mineralogically, its composition being identical in both cases. The vein-rock is a yellowish or bluish, very uniform aggregate of fragments of serpentine and mica of unvarying size, with small and sparse fragments of accessory minerals. In general appearance and texture, it resembles a doleritic diabase. But the pipe-rock, on the other hand, is extremely variable, the groundmass consisting all but exclusively of serpentine while the tiny flakes of mica that do occur are barely visible. Accessory minerals are very abundant, often in the form of big well-developed crystals. The coarsely granular structure of the pipe-rock recalls plutonic rocks which have solidified under pressure.

It may, therefore, be inferred that the vein-kimberlite solidified under conditions different from those under which the pipe-kimberlite solidified. The veins are almost invariably arranged in parallel series, and can thus be followed for mile after mile across country; while the pipes, although in a way grouped together, occur in sporadic batches, and are evidently of later origin than the veins. At great depths their cross-section is almost exactly circular, and makes one think of the effect of an old-fashioned cannon-ball being shot through a partition.

Although both varieties of kimberlite belong geologically to the same horizon—that is, to a time when the deposition of the Karoo sediments had begun, their protrusion took place at two different stages: the vein-kimberlites first welled up through contraction-fissures in the earth's crust, widening these fissures as they did so, and sweeping along with them fragments of the country-rock. Thereupon, the mass of the deep-seated kimberlite-magma having thus suffered a diminution, pressure on the remainder of the magma was so far released as to cause it to resume the fluid state, and to cause the associated water to flash into steam, sufficient dynamic energy being thus produced to permit of an explosive uprush of the magma forming the pipe-kimberlites. But the farther up they travelled, the more they lost in explosive energy; the associated gases escaped through various fissures; and all that the upwelling magma was then capable of, was to thrust up to a certain

extent the overlying rocks and to squeeze itself out laterally after the manner of a laccolite. L. L. B.

NEPOUITE, A NEW NICKELIFEROUS MINERAL.

Note sur une Espèce minérale nouvelle : la Népouite, Silicate hydraté de Nickel et de Magnésie. By E. Glasser. *Bulletin de la Société française de Minéralogie,* 1907, *vol. xxx., pages* 17-28.

All the hydrated silicates of nickel and magnesia which have been thus far described, whether from New Caledonia or elsewhere, occur in amorphous masses, although occasionally (and especially in noumeite) microscopic investigation reveals the presence of a cryptocrystalline structure recalling that of chalcedony. Recently, among several lots of nickel-ore specimens collected by the author in New Caledonia, he discovered certain silicates, in many respects chemically similar to garnierite and noumeite, but undoubtedly crystallized and possessed of very different optical properties from those exhibited by the two last-mentioned minerals. The new mineral occurs in the form of minute, roughly hexagonal flakes, frequently adpressed one against the other so as to constitute vermicular aggregates analogous to those formed by the chlorites. It is found as an extremely fine, ashen-green, crystalline dust among the complex débris that fill up the interstices between the more or less crumbly blocks of nickeliferous serpentine, which latter often constitutes the best ore that is to be got in the island. Detailed analyses are tabulated of five specimens, and the author proposes for the mineral the formula: $2\,SiO_2 . 3\,NiMgO . 2\,H_2O$. The name assigned to it, nepouite, is derived from Nepoui, the locality whence it was first obtained. The specific gravity is variable (2·47 to 3·24), and appears to depend on the amount of nickel which any given specimen may happen to contain, increasing, of course, in the same ratio as the percentage of that metal; this statement holds good also of the green coloration of the specimen, which is the more vivid the richer it is in nickel. The hardness lies between 2 and 2½. In those specimens wherein the proportion of magnesia is small, the high percentage of nickel (39) present in nepouite is another characteristic by which it may be distinguished from garnierite and noumeite. L. L. B.

PARAVIVIANITE AND KERTCHENITE, TWO NEW MINERALS.

Ueber zwei neue phosphorhaltige Mineralien von den Ufern der Strasse von Kertsch. By S. Popoff. *Centralblatt für Mineralogie, Geologie und Paläontologie,* 1906, *pages* 112-113.

These minerals occur among the limonite-ores of the peninsula of Kertch and Taman, in the far south of Russia.

Paravivianite, in transparent, acicular, bluish crystals, has a specific gravity of 2·66 to 2·67, hardness somewhat over 2, and yields a bluish streak. It corresponds in composition to the chemical formula: $(FeMnMg)^3 P_2 O_8 + 8\,H_2O$, contains 39·12 per cent. of ferrous, but no ferric oxide, 27·01 of phosphorus pentoxide, and 2·01 per cent. of manganous oxide.

Kertchenite is in the form of flat tabular crystals arranged in fibrous radial aggregates, dark-green verging on black, has a specific gravity of 2·65, hardness 3·5, and yields a green streak. It corresponds in composition to the chemical formula: $(FeMnMg)O . Fe_2O^3 . P_2O_5 + 7\,H_2O$, and contains, on an average, 32·93 per cent. of iron peroxide, 9·49 of ferrous oxide, 28·2 of phosphorus pentoxide, and 1·92 of manganous oxide. L. L. B.

for Russia (until recently), Brazil, India, and Cuba, while the output has remained practically stationary in the United States, Prussia, Spain, Austria, and Italy. The importance of Russia as a factor in the world's supply may be gauged from the figures of her output of manganese-ore in the year 1900; namely, 884,200 tons. She seems to possess practically a monopoly of high-grade ore, and (given political tranquillity) her output seems to be still capable of enormous expansion. It is true that the methods of working, in the Caucasus, for instance, leave much to be desired; it may be inferred that they are both primitive and wasteful. The amount of manganese-ore in sight in the Caucasus is estimated at 98,000,000 tons, and in the Nicopol district of Southern Russia at 40,000,000 tons; no statistics are forthcoming in regard to the other districts.

Germany is by no means poor in manganiferous deposits, but the output from the different mines is comparatively small. The extreme irregularity of the deposits, however, is an element of risk which the prudent capitalist must needs take into account.

Turning then to the consideration of the mining of manganese-ores, the author remarks that this is a subject of not very absorbing interest for the practical miner, as the almost universal conditions of the deposits are such that underground or deep-level workings hardly come into account. It is true that in the Caucasus there are some underground workings, where the deposits have a seam-like character; but even these can generally be reached by adits opened up in the hill-sides. In Brazil and India, the deposits lie so near the surface that the conditions are extremely favourable for open-cast working. The author reproduces several photographs of Indian, Turkish, and Caucasian mines, and tabulates 96 chemical analyses (previously published by various authors) of Russian, Italian, Spanish, French, Brazilian, Chilian, Indian, Japanese, Panama, United States, Bosnian, and Greek ores. With regard to the geological characteristics of manganiferous ore-occurrences, the reader is referred to Mr. Léon Demaret's great memoir on those deposits.*

A catalogue is then given of the most important occurrences throughout the world, the whereabouts of which are indicated on the two maps that accompany the paper; and the author concludes that the necessary supply of manganese-ores for the iron-and-steel industry of all countries is assured for a long time to come. The Caucasus alone could furnish the necessary million tons or so for another century; and to this may be added the output from other parts of Russia, from Chile, Brazil, and India. A bibliographical list is given of the publications of which use has been made in the compilation of this paper. L. L. B.

KARÁCS-CZEBE GOLD-MINES, HUNGARY.

Die Goldgruben von Karács-Czebe in Ungarn. By KARL VON PAPP. *Zeitschrift für praktische Geologie*, 1906, *vol. xiv., pages* 305-318, *with* 5 *figures in the text.*

South of Körösbánya in Hunyad county, the Magura and Karács hills are girdled round with auriferous deposits which were at one time successfully mined, but are now in such a state of abandonment that most of the workings have fallen in. In the summer of 1905, in the course of his geological survey of the district, the author had an opportunity of personally investigating these deposits, partly with the view of determining whether they really constitute the choicest morsel of the Transylvanian gold-belt, and

* *Annales des Mines de Belgique.*

whether consequently the resumption of mining operations would prove feasible.

It is necessary to clear one's mind of Dr. F. Pošepny's postulated triangle of gold-mines in this area: as a matter of fact, the Transylvanian gold-bearing district covers an irregular quadrilateral, the respective angles of which are determined by the four localities, Offenbánya, Zalathna, Nagyág, and Karács. Outside this quadrilateral, Transylvania can boast of no existing or prospective gold-mine of any consequence. The oldest formations in the district are a dirty-green mélaphyre and a flesh-pink quartz-porphyry, with which are associated tuffs scarcely to be distinguished from the solid rock, all of Triassic age. On the whole, they are not rich in metalliferous ores: nevertheless, pyrites occurs in them at Kazanesd and Felvácza, and also valuable copper-ores at Almásel. In some places, reef-limestones of Jurassic age rest upon these rocks, and are in turn succeeded by the Carpathian Sandstones of Cretaceous age. The sandstones are overlain by red clays and coarse-grained drifts, which form the floor of the Miocene brown-coal deposit. The summits of Karács (2,750 feet) and Magura (2,493 feet) are built up of andesitic lava-flows which date from Miocene and Sarmatic times. Later on, the fumaroles and solfataras of the decrescent phase of vulcanicity silicified and altered the rocks, while ores were deposited in the fissures. This process of deposition appears to have occupied a considerable interval of time: at all events, the deposits of gold and other noble metals were being formed, from the Sarmatic period onward into Pontic or Pannonian time. The Karács rock is predominantly hornblende-andesite, in part weathered to kaolin: and the gold-mines have been opened up in a mighty angular breccia of andesite and dacite-fragments.

Here occurs the famous lode of Czebe, which is probably a gigantic fissure-vein. It was the belief of the old miners that the lode is richest near the surface, and that there is progressive impoverishment in depth; this, however, has proved untrue of the neighbouring Ruda mines, and, although the deep-level adit at Czebe has not as yet yielded workable ores, there is some reason to think that it will do so when driven for the proper distance into the hill. The gold occurs in a rusty-red plastic china-clay, raddled by limonite and manganese-ores. It is rarely in the free state; among the associated minerals are sylvanite (telluride of gold and silver), nagyágite (tellurisulphide of lead and gold), pyrites, galena, blende, rhodochroisite, etc.

The usual agencies of erosion have heaped up coarse gravels in the Körös valley, among which gold-dust is disseminated, and that most abundantly where the elements of the gravel are coarsest. Of this fact, the ancient Romans were not unobservant, and traces of their industry are still noticeable at the confluences of streams where the gold-bearing alluvial fans spread out. But the gold-mining industry of the region dates much further back even than the Roman dominion. The author sketches briefly the history thereof down to recent times, and reckons that 401,875 ounces of gold, in all, were got in the district during a period of 2,000 years. He also describes seven abandoned mines, and estimates the gold that might still be got from them and from the alluvia as amounting to 113,000 ounces. In regard to future working, the essential procedure would be to drive a deep-level exploration-adit, using for that purpose the Rosenfeld adit, which has already been driven 1,518 feet, but caved in several decades ago. A sufficient water-supply for mining purposes for a 3- to 6-stamp battery would be permanently available by utilizing the waters of the Körös stream, some 3¾ miles distant.

L. L. B.

MINERAL INDUSTRY IN RUSSIAN CENTRAL ASIA.

Das Berg- und Salinenwesen in Russlands mittelasiatischen Besitzungen. By F. THIESS. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., Abhandlungen, pages* 189-197, *with* 3 *maps in the text.*

The provinces of Transcaspia, Samarkand, Ferghana (including the Russian Pamir), Syr-Daria, Semiryetshensk, and the two vassal states of Khiva and Bukhara, cover an area of close upon 790,000 square miles, and are now all included in the designation "Russian Turkestan." This region, which is as big as the German and Austrian Empires, France, Italy, and Denmark put together, extends for some 1,660 miles from south-west to north-east, and its greatest breadth is 930 miles (from north to south). The greater portion consists of sandy desert with artificially-irrigated oases, loam- and lœss-covered steppes, and pasturages with salt-marshes, the greatest depressions being 147½ feet below the level of the Caspian, and the highest undulations in the Turkestan plain attaining an altitude of 1,000 feet above the level of the same inland sea. Apart from this, however, a quarter of the entire area is mountainous, being traversed in the south-east, east, and north-east by ramifications of the Tian-Shan and Alaitagh ranges.

The great Central Asian railway, 1,570 miles long, traverses the entire region, and is now linked up with the railway-system of Russia-in-Europe by means of the Orenburg-Tashkent line. With the construction of the railway has coincided an active investigation of the mineral resources of the country on the part of its new masters; and the foundations have been laid for an industry on modern lines, in lieu of the present, generally primitive, method of conducting mining operations in that part of the world.

Beginning with the province of Transcaspia, 88 per cent. of the 233,575 square miles which it occupies is desert, the remaining 12 per cent. being arable land. Brown-coal is known to occur in the Mangishlak peninsula in the far north-west and on the Tuar-kir heights in the district of Krasnovodsk. Sulphur occurs in various localities, and has been worked by the natives in the Kara-Kum desert, where bands of sulphur of variable thickness are interbedded with the Tertiary marls in certain isolated hills. Brown hæmatite has been proved in the Kara-tau mountains on the Mangishlak peninsula. The salt-lakes are of considerable importance, yielding besides rock-salt what is in Russian called *samosadótshnaya solye* (self-separated salt) from deposits in actual course of formation along their edges. The total output of salt from the province in 1901 amounted to 16,638 tons, whereof 12,495 tons came from the great rock-salt deposits of Tsheleken island, only 323 from Balla-Ishem (where, however, there are 3½ million tons of rock-salt in sight), and 3,820 tons of "self-separated salt" from the salt-lakes. The Glauber-salt deposit at the bottom of the shallow Kara-Bugas gulf increases in thickness by 0·4 inch every year: it is said to cover an area of 1,235 square miles, and the quantity of available mineral is estimated at several million tons. Since 1901, the deposit has been worked by private enterprise, and detailed information is not forthcoming.

Even before the Russian conquest, the Turcomans tapped for domestic purposes the natural oil-wells in the Nafta-Dagh and the Buja-Dagh; from the former range the railway-station of Balla-Ishem is only 20 miles distant, and so the Russian engineers in 1882 tapped springs of petroleum at depths of 400 to 550 feet, and made use of the oil for driving the locomotives and lighting and heating the stations along the line. Since then, fresh oil-wells have been

tapped in the same locality. The petroleum-deposits on the Island of Sheleken are actively worked, and the oil is sent in tank-steamers to the Baku refineries. In 1902, the total output of crude petroleum from Transcaspia amounted to 10,500 tons (say, 2,311,000 gallons). Asphalt-deposits are known to occur in the Balkhan-Dagh, gypsum in the neighbourhood of Krasnovodsk, and many thermal springs are visited throughout the province for their curative properties. Limestone is quarried in the Kopet-Dagh and other localities.

In the province of Samarkand, bituminous coal has been proved at a score of localities at least, and in a dozen instances these are not far from the railway. Among other minerals may be mentioned anthracite, graphite, calamine, antimonite, ores of lead, copper, and manganese, native sulphur, and turquoises. Five coal-mines are at present in operation, but their total output in 1901 amounted to barely 8,000 tons. The fissuring of the strata is one of the great difficulties with which the Samarkand miner has to contend; and it must be remembered that the rule is to work only for the first five months of the year, although one or two mines are at work all the year through. The coal is taken, over very bad roads and bridle-paths, by pack-camels to the centres of population. The miners' wages average 1s. 6d. *per diem*, the prime cost of the ton of coal ranges as high as 13s., and the freight, etc., may amount to 26s. per ton. In Tashkent itself in 1895 the retail price amounted (for small quantities) to as much as 52s. 6d. per ton of coal, and in Khodshent (one of the coal-districts) to 31s. 6d.

Bituminous coal is found in every district of the province of Ferghana, except that of Osh. Anthracitic and graphitic deposits occur in the Karategin-Dagh. Placer-gold is found in the Muk-su torrent, and the primary auriferous deposit is suspected to occur in the narrow and hardly accessible ravine of Saok-sai, whence the Muk-su issues. Petroleum, rock-salt, and lake-salt are found in many localities, and cinnabar, sulphidic ores, and various ores of lead, copper, and iron are of fairly widespread occurrence. Copper-ore, containing as much as 60 per cent. of the metal, was discovered in 1905 at Naukat on the Syr-Daria, and smelting-works are now being erected there. Three sulphidic ore-mines are worked in the district of Khokand, and one coal-mine in that of Namangan. The salt-output from the province in 1901 amounted to 11,466 tons. The numerous occurrences of petroleum can be traced to two distinct belts—a north-easterly extending some 26 miles through the districts of Namangan and Andishan, and a south-westerly extending no less than 66 miles through the districts of Marghelan and Khokand. In many places mining operations have begun only as recently as 1905.

In the Syr-Daria province, the occurrence of coal, lead, copper, and iron-ores has been proved. Only one coal-mine is at present worked, in the Kara-tau mountains of the Tshimkent district: the comparatively insignificant output, 300 tons or so *per annum*, is used for heating the Government buildings in the city of Tashkent, and for industrial purposes. Rock-salt and lake-salt occur in many localities; but the deposits are almost exclusively worked by the natives, the annual output amounting to 3,000 tons or more.

The province of Semiryetshensk is, for the greater part, mountainous country, and but little prospecting work for useful minerals has been accomplished therein so far. The occurrence, however, of coal, graphite, gold, lead- and copper-ores, rock-salt and lake-salt, etc., is more or less established, although in many cases the unconfirmed statements of the Kirghizes constitute the only available data. L. L. B.

WORKING OF NATIVE SULPHUR IN SICILY AND IN LOUISIANA.

Note sur les Conditions économiques de l'Exploitation du Soufre en Sicile et en Louisiane. By L. AGUILLON. *Annales des Mines*, 1906, *series* 10, *vol. x.*, *pages* 599-617.

The sulphur-industry in Sicily, which until recently, so to speak, could lay claim to the production of 90 per cent. of the world's output of sulphur, was, from the year 1860 until 1883 in a phase of continuous development. Since the last-named year it has been subject to frequent and considerable oscillations. After a period of depression lasting until 1890, there was in that and in the following year a short interval of long-unexampled prosperity, succeeded in 1893 to 1895 by a continuous fall in prices such as to make the greater number of the sulphur-mines economically unworkable.

Apart from a few large estates, landed property in Sicily is cut up into innumerable small holdings, and the right of quarrying the sulphur is attached to the ownership of the surface-soil. But the small landholder, as a rule, is no prospector, nor does he attempt to work the mineral-deposits which may occur on his property: he prefers, indeed, to let someone else work them on payment of a royalty (*estaglio*) equivalent to 15 or 30 per cent., or even more of the gross output. The mines are usually of very small extent, and this limitation of area is a hindrance to rational methods of working. The number of such mines increased from 480 in the year 1890 to 777 (actively at work) in 1905, in which year the total output amounted to 535,782 tons; but the output from 679 of these workings averaged rather less than 200 tons apiece. The lessees who work the smaller mines borrow the necessary funds, at an exorbitant rate of interest, from the warehousemen with whom they deposit their sulphur as security. One per cent. of the sulphur also goes to the warehouseman in lieu of rental, and there are other onerous conditions which justify the author in characterizing the system as usury naked and unashamed. The consequences, to the lessees and the 40,000 work-people employed in the mines, are disastrous at times of low prices; as in 1895, when the Italian Government, by way of palliative measures, suppressed the export-duty and granted a fixed bounty on every ton of sulphur shipped. Yet even this would have been inadequate, but for the constitution in 1896, at the worst of the crisis, of a strong British company which, by an agreement with the Italian Government, undertook to purchase, at a fixed price according to quality, all the sulphur produced in Sicily. This resulted immediately in a rise of prices, and in the liberation of the sulphur-producers from the toils of usury. The Company prospered exceedingly, paying dividends of 50 per cent. on the ordinary shares, but was wound up on July 31st, 1906, at the termination of its second quinquennial agreement. The stock of sulphur which it had then on its hands was practically equivalent to the output of a whole year; the annual output, by the way, had continuously increased from 353,000 tons to 535,782 tons in 1905.

Silician sulphur had now met with a formidable rival in the world's markets, in the shape of the mineral from Louisiana, and the once considerable export to North America had dwindled to half its former amount within three years. The Italian Government thereupon promulgated the law of July 15th, 1906, which, from the date of the ensuing first of August, constituted a legally compulsory syndicate of the owners, lessees, and workers of all the sulphur-mines in Sicily then existing or thereafter to be opened up, for the space of twelve years. The syndicate alone is empowered to place sulphur on the market, and the mineral can neither be carried by railway, nor shipped by

sea, without a permit from the syndicate. Infractions of the law are punishable by the criminal, as well as by the civil code. This law applies, of course, to the crude sulphur (*solfo grezzo*) alone: the industries that are concerned with the refining, grinding, and sublimating of sulphur, remain unaffected by it, but they have to purchase the raw material from the syndicate.

Various supplementary provisions are explained, such as the constitution of a benevolent fund for the benefit of those who would be thrown out of work by a reduction in output; the measures for dealing with the stock inherited from the British company, and for the fulfilment of contracts previously entered into for future delivery. Details are given as to the administrative council, headed by a director-general nominated by the King of Italy, and the committee of delegates of 50 members, who conduct the affairs of the new syndicate. By means of a temporary royal commission, consisting of only five members, the transition from the old *régime* to that now in force was accomplished without a hitch. Careful arrangements were made in regard to finance, warehousing, remission of burdensome taxes, etc.; nothing, in fact, was omitted in this legislation, for which an analogy would be vainly sought in any other country. Admitting that the new law apparently contravenes most of the old-established principles of liberty of contract, freedom of labour, rights of property, etc., the author points out, on the other hand, that the circumstances of the Sicilian sulphur-mining industry are so very exceptional, that they justify such an heroic remedy as the drastic intervention of the State sanctioned by this law.

The deposit of native sulphur which is now being worked in the great coastal plain of Louisiana occurs at the base of the Miocene, in a group of clays and sands, which also yield gypsum, natural gas, and petroleum, in the parish of Calcassieu, 11 miles or so west of Lake Charles, and 15½ miles distant from the Sabine river, which forms here the boundary between Texas and Louisiana, and is navigable by sea-going vessels. It was in the course of boring for oil that, in the year 1868, a bed of pure crystallized sulphur, 105 feet thick, was struck at a depth of 436 feet from the surface. Later on, endeavours to sink a shaft to this bed by the Kind-Chaudron process were defeated, as it was found impossible to get through the quicksands and water-bearing beds. Meanwhile new borings revealed the existence of other masses of native sulphur, the total amount of pure mineral in sight being then estimated at 3,000,000 tons.

Thereupon, in the year 1895, a syndicate was formed to work the deposits by means of the Frasch process. This consists essentially in melting the sulphur *in situ*, by injecting through a boring, carried down to the floor of the deposit, water heated to 334° Fahr. at a pressure of 16½ pounds per square inch, and in bringing the molten sulphur to the surface by blowing into it air compressed at 28 atmospheres, in such wise that the specific gravity of the ærated column of sulphur is less than that of the descending column of superheated water. The water is injected in an external column, the sulphur ascends in an internal column, and the compressed air descends in an intermediate column. At the surface, the sulphur flows into great reservoirs built of wooden planking; and, when solidified, the mass is broken up into portions suitable for shipping. It is only since 1903 that the process, after repeated and costly trials, has become industrially applicable on this great scale. Meanwhile, the true extent of the sulphur-deposits has been more definitely ascertained: over an area of at least 64 acres, below from about 490 to 625 feet of barren covering strata, they form on the whole a practically horizontal mass varying in thickness from 200 to 330 feet, and may amount

to 40,000,000 tons (as compared with 54,000,000 tons, the total estimated mass of the native sulphur-deposits of Sicily). The local conditions are favourable to the working of the Frasch process, which consumes an enormous amount of steam. Petroleum for oil-fuel is obtained very cheaply from Beaumont in Texas, not 50 miles distant; and water is brought by a canal, 3½ miles in length, from the Houston river, a tributary of the Calcassieu. Three bore-holes are worked simultaneously, about 100 feet apart; the installation and putting down of each bore-hole, everything included, costs from £520 to £840, and can be completed in a month. The sulphur obtained by this process is remarkable for its purity. L. L. B.

GOLD AND SILVER-MINES OF ARZATE, MEXICO.

Reseña del Mineral de Arzate (Estado de Durango). By JUAN D. VILLARELLO. *Memorias de la Sociedad científica "Antonio Alzate,"* 1905, *vol. xxiii., pages* 211-239.

The Arzate metalliferous deposits, upon which exploration-work was first re-started in the course of 1899, occur in the sierra of the same name, in the commune of Pámeco, department of San Juan del Réo, State of Durango, in the neighbourhood, more or less remote, of several other metalliferous occurrences which were actively worked in the days of the Spanish overlordship.

The geology of the sierra is simple enough, as there are no outcrops of sedimentary strata, and the range is built up mainly of pink rhyolites showing fluidal structure, of Pliocene age, overlain by vast basalt-flows dating from the Pleistocene. Three systems of fissures traverse the rhyolites, and some of them are mineralized, forming lodes of extremely variable thickness. The outcrops of these lodes are marked by gossans of quartz and iron-oxides, with which is associated a small quantity of native gold; but both lodes and gossans are entirely cut off by the Pleistocene basalts.

The workings of the Independencia mine have opened up a vein wherein the metalliferous ores form small, irregularly dispersed lenticles, the industrial value of which diminishes as the depth from the surface increases. For, although the quantity of silver contained in the ores augments proportionately with the depth, that of gold correspondingly decreases: thus, the stuff got from the upper portion of the workings yields 1·6 ounces of gold and 2·56 ounces of silver per ton, while that from Hidalgo shaft yields only 0·256 ounce of gold, but 5·6 ounces of silver.

North-east of the Independencia mine is the Libertad mine, working a lode which strikes parallel with that opened up in the former mine. Its thickness at the surface measures 20 inches, but diminishes in depth until from 65 feet downward it is just 0·8 inch. The vein is mineralized with ferruginous quartz, oxides of iron, a small quantity of pyrite, native gold in granules, etc., and a very small amount of embolite (chlorobromide of silver); these, as in the previously-described case, occur in irregularly dispersed lenticles of no great size, which are perhaps, if anything, of less industrial importance than the metalliferous lenticles of the Independencia mine.

The northernmost mine hereabouts, that of La Cruz, has opened up a lode about 12 inches thick, yielding on assay 0·16 ounce of gold and 2·43 ounces of silver per ton.

The author explains at some length his reasons for not regarding these lodes as true fissure-veins: he classifies as the primary minerals therein the rather sparsely distributed pyrite and the quartzose gangue; as secondary minerals (due to the downward percolation of surface-waters), the hydrated oxide of iron, the small quantity of native gold, and the minute percentage of

embolite. As to the age of the lodes, from what has been already stated it follows that they were formed subsequently to the consolidation of the rhyolites and before the eruption of the Pleistocene basalts; in fact, they probably date from the late Pliocene. It seems probable that, when the underground water-level of the country is reached by the mine-workings, the zone of the original sulphides will be simultaneously reached; and therewith the various silver-bearing ores will be found in the lodes, but containing still less gold than the portions already explored.

The question of the origin of these deposits is discussed at great length, and in a general classification which the author proposes he ranks them as magmatogenic and catamorphic, that is, formed by the elimination of aqueous constituents (dishydration) from the deep-seated portion of the magma which produced the rhyolites, and mineralized by metasomatic substitution. The very unequal thickness of the lodes and the frequent indefiniteness of the boundary between them and the country-rock favour the metasomatic hypothesis. It remains to be said that the deposits are situated some 10 miles to the north-west of the Gabriel station on the International Mexican Railway, and that the water-supply of the district is scanty—consumers being mainly dependent for this article of necessity on rain-water tanks. L. L. B.

METALLIFEROUS MINES OF ZACUALPAN, MEXICO.

Descripción de algunas Minas de Zacualpan (Estado de México). By JUAN D. VILLARELLO. *Memorias de la Sociedad científica "Antonio Alzate,"* 1906, *vol. xxiii., pages* 251-266.

These mines are situated in very rugged country in the Sultepec district of the State of Mexico, some 37 miles south of Toluca, the capital city of that State. The exploration and working of the deposits date back as far as the early days of the Spanish conquest, while fresh finds as recently as 1897 momentarily galvanized into life the ancient mineral industry of the region, and for three years thereafter a vast quantity of rich ore was got and sent off from Zacualpan.

The rocks of the country consist (1) of black or bluish-grey Cretaceous shales, both argillaceous and calcareous, occasionally metamorphosed into apple-green chloritic schists, striking north and south and almost horizontally bedded; and (2) of intrusive hornblendic andesites of Tertiary age, which cut across, invade, and metamorphose the above-described sedimentaries. All the rocks alike are traversed by three distinct systems of fissures, none of which have caused sufficient dislocation to be regarded as true faults. They extend from Zacualpan through Chontalpa and Pregones, towards Noxtepec and Taxco, and throughout that vast area many of the fissures are richly mineralized—the principal ores being pyrargyrite, argentiferous pyrite, galena, zinc-blende, etc., of the primary infilling; and oxides of iron, native silver, and argentite, the outcome of the secondary differentiation of the infilling, these latter being known locally as *ixtajales*. The gangue is either predominantly quartz or predominantly calcite, more often the former.

At El Moral mine, the best-known lode is the San Miguel, striking generally 50 degrees north-west, dipping north-eastward, averaging 3¼ feet in thickness, and well marked off from the hornblendic andesite through which it courses. Its mineralization varies with the depth: thus, from the surface down to the first level, argentiferous galena occurs in small quantity, while pyrargyrite and amorphous pyrite are abundant; between the first and the second levels, argentiferous galena abounds, the percentage of silver increasing concurrently with the depth, while pyrargyrite and pyrite are

scarce. The ores occur within the quartzose-calcitic gangue in the form of long thin lenticles, locally termed *botones*, the most extensive lenticle yet discovered measuring 174 feet from the surface downwards (which represents the greatest depth as yet reached by the workings). The San Carlos lode, striking between 20 and 30 degrees north-west, and dipping north-eastward, also traverses the andesite. It is of extremely irregular thickness, often trailing out into mere stringers, while occasionally it broadens out to over a yard. The gangue is predominantly calcite, with a little quartz; irregularly dispersed within it are masses of pyrite and argentiferous blende. Deeper down, galena makes its appearance, while the previously-mentioned ores are occasionally found concentrated in small lenticles. East of the San Miguel, three other parallel veins bearing similar ores have been the object of exploration-work; while those to the west of the lode had not yet been prospected at the time of the author's visit.

In La Providencia mine, four lodes traversing the argillaceous shales contact-metamorphosed by the andesite, have been prospected: they vary in thickness from 2 inches at the surface to 4 inches at the greatest depth yet investigated, and consist of quartz mineralized with argentiferous galena and a small quantity of auriferous pyrite.

At La Reforma mine, three lodes, similarly traversing the metamorphosed shales, contain pyrargyrite, pyrite, and argentiferous galena, irregularly disseminated in a gangue of quartz. In thickness they vary between 20 and 28 inches, and, in what the author terms the "lixiviation-zone" or zone of leaching, occur the secondary ores, the *ixtajales* (oxides of iron, with a little native silver and argentite). Two of these lodes strike north and south, being intersected by the third, which strikes 15 degrees north-east; and enrichment occurs at the points of intersection. One gathers that these ores have been largely worked out.

Considering that the above-mentioned lodes cut through the Tertiary andesites as well as the Cretaceous sedimentaries, they must be younger than the former, and probably date from the Pliocene period. It has already been mentioned that the lenticles of metalliferous ore are met with continuing from the surface downwards to great depths, the percentage of silver increasing concurrently with the depth. But lower down than 500 feet, impoverishment sets in, the infilling becomes almost exclusively quartzose; and, on this barren horizon being reached, exploration-work was stopped.

The author regards these mineralized fissures as due to the dynamic effects of pressure, the more so as they appear to form conjugate systems: that is, they strike on the whole parallel one to the other, with contrary dips. No characteristically contact-metamorphic minerals are found in the infilling, or in the immediately contiguous "country-rock," which is merely silicified (in places) adjacent to the lodes. These were probably infilled by metalliferous particles derived from the thermal waters percolating upwards through the rocks; but metasomatic replacement also played a part in the infilling.

The picked ores got from the San Miguel lode yield on an average 10 to 20 per cent. of metallic lead and 58 ounces of silver per ton. Those from the San Carlos lode, after sorting, yield from 26 to 32 ounces of silver per ton; and those from La Fortuna mine, the workings of which are flooded and have caved in, yielded (after sorting) from 32 to 96 ounces of the precious metal per ton.

Generally speaking, the local conditions are such as to favour the economic development of a mineral industry. L. L. B.

USE OF EXCAVATORS AT THE BROWN-COAL MINES OF PRUSSIAN SAXONY.

Die Verwendung von Baggern zur Abraumarbeit auf den Braunkohlenbergwerken der Provinz Sachsen. By M. TORNOW. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate,* 1906, *vol. liv., pages* 568-595, *with* 5 *figures in the text.*

The recent enormous development of the German brown-coal industry is exemplified by the official statistics issued for the mining district of Halle, which show that the annual output for that district has increased from 9 million tons (in round figures) in 1880 to 34 million tons in 1905. This development has been especially marked within the last decade in Central Germany, and here the fierce combat which producers have to wage with their Bohemian rivals (one of the incidents of the struggle being a continuous decline in prices for the past quarter of a century), makes the smallest economy in working a factor of vital importance.

During the fifteen years that have just elapsed, the Central German opencast workings have reached the phase of enterprises conducted on a colossal scale, some of them being ¾ mile in length and more. The older method of quarrying, still pursued in several localities, has largely given way to the system of removing the cover by means of excavators, the economic limit of the proportion of cover to brown-coal being 2 to 1. The removal of the cover by manual labour would now be too costly, the scarcity of this labour is too marked, and the necessarily restricted size of the tipping-wagons under such circumstances too small, to admit of success in the commercial struggle to which reference has already been made. The introduction of excavators has facilitated opencast working on a large scale, with the resulting advantages that industrial operations on such a scale always imply.

In the spring of 1906, about sixteen excavators were at work in the brown-coal mines of the Prussian province of Saxony. But the mere citation of this number is far from representing the extent to which use has been, and is being, made of these appliances: in many cases the cover has already been excavated off considerable areas, and in others the excavators are only brought into action at intervals. If the above-quoted number were doubled, this would perhaps convey a more accurate idea of the present state of affairs. The excavators are each capable of dealing with a minimum of 28,000 cubic feet of material in a 10 hours' shift; and, on an average, they deal with from 42,000 to 52,000 cubic feet in that time, while those of the latest type have been known to deal with 87,500 cubic feet of material. Shovel and scraper-excavators are not used at these mines, the most favoured type being a deep-working bucket-chain excavator. The maximum depth to which these work exceeds 52 feet, the motive power universally applied being steam at a pressure of 7 to 8 atmospheres. An engine of 60 to 80 horsepower is found suitable for such excavators as deal with 52,000 to 70,000 cubic feet of material in a 10 hours' shift. The engine works at high pressure, regulated by a throttle-valve, and there is consequently some waste of heat. As to fuel, ordinary briquettes (on account of convenience of stacking) are preferred by some mine-owners; while others make use of small coal or of brown-coal briquettes. The author utters a warning as to the feeding of the boilers with unpurified pit-waters; owing to the percentage of sulphur present in the brown-coal, these generally contain a certain amount of sulphuric acid. The guidance of the excavator, with its various levers, demands considerable skill on the part of the man in charge; in fact, it is on him that the full

development of the capabilities of the apparatus depends. The excavators run on two or three heavy rails; in the case of especially heavy machines, so-called Goliath rails are laid down, measuring from 5·4 to 5·8 inches in height, and weighing not far short of 100 pounds per lineal yard.

The excavated material is removed in tipping-wagons of 105 to 157 cubic feet capacity: a mine will use on an average forty to fifty of these, sufficient to make up two trains and allow of a reserve stock being maintained. Increasingly powerful locomotives (from 80 to 125 horsepower) are being run with these, on tracks of 2 to 3-foot gauge; the rails are almost universally 5·4 inches in height, and weigh rather more than 70½ pounds per lineal yard.

The most advantageous position for the tip-heaps, and the most expeditious methods of loading the wagons, despatching the trains, and tipping their contents, with the view of realizing the greatest possible economy in working, are considered by the author in some detail. He also describes the local conditions, which sometimes necessitate the preliminary labour of levelling the land-surface and clearing it of forest-growth.

With regard to the nature of the cover that has to be removed, it varies greatly from place to place: Tertiary beds are often wanting above the brown coal. In the western districts of Prussian Saxony, especially around Bitterfeld, the coal is overlain by a bed of (occasionally) extremely pure clay, which furnishes the raw material for a flourishing pottery-industry and attains a thickness of 13 feet. Over this comes a still thicker bed of highly arenaceous gravel, in which erratic boulders of considerable size are of frequent occurrence, topped by thinner bands of lœss or sand, the total thickness averaging 40 to 50 feet. In the eastern districts of the province, on the other hand, the cover is mainly composed of very easily removable sands, in which boulders rarely occur. The boulders, as might be expected, constitute one of the chief difficulties with which the excavators have to contend; not only do they cause much waste of time, but also on occasion destructive damage to the buckets or to the chain.

The removal of the cover generally precedes by a little the winning of the brown coal. The mineral is usually laid completely bare, without (apparently) much regard for the risks arising from the possibility of spontaneous combustion by slow oxidation in the open, and from the possibility of the coal being set alight by sparks from the locomotives, etc. Mine-owners have, indeed, been advised to protect the brown coal by leaving over it a thickness of 20 to 40 inches of cover, but they universally fight shy of the inevitably resulting expenditure on removal by hand, enhanced in cases where the surface of the coal is uneven. It is customary, where a pumping-plant is available, to adopt the precaution of spraying the uncovered coal on hot summer-days, in order to keep it to a certain extent moist.

The author points out that the economic success of the excavator-system depends primarily on the avoidance of pauses. There must not be a moment wasted, all through the process: this naturally involves skilled superintendence and high-class labour, and even so is rendered by circumstances occasionally impracticable. As to costs, a long series of examples is set forth in full detail, and, taking all the available data into consideration, the author concludes that the prospects of a further development of the excavator-system are decidedly favourable. In fact, he regards that system as having already become an indispensable factor in the successful working of the brown-coal mines of Prussian Saxony. There is, moreover, an idea afloat of utilizing the excavators for winning the coal itself, as the toughness of the mineral is not sufficient to affect prejudicially their working any more than would,

let us say, a stiff clay. The possible comminution of the brown coal in the process of excavating would not be considered much of a disadvantage, as in many mines the entire output is manufactured into briquettes.

L. L. B.

DYNAMITE-EXPLOSION AT THE ZAPPENDORF BORE-HOLE, GERMANY.

Die Dynamitexplosion in dem Bohrthurme bei Zappendorf am 4. Mai 1906. By — BEYLING. *Zeitschrift für das Berg, Hütten- und Salinen-wesen im preussischen Staate,* 1906, *vol. liv., pages* 671-675, *with* 1 *figure in the text.*

In the spring of 1906, a deep bore-hole, in search of potassium salts, was put down in a concession belonging the Krügershall Salt-mining Company, immediately south of Zappendorf station on the Teutschenthal and Salzmünde railway. Boring operations were attended with great difficulties, as, on account of the disturbed condition of the rocks, the boring-tool continually stuck fast. When this happened once again, at a depth of 708 feet, all the known technical methods of setting the tool free were unavailingly applied, and consequently the engineers resolved to blast it away with dynamite.

Experiments were made with a magneto-electric igniter, in order to determine whether it worked properly, and several fuses (coated over with wax to preserve them from damp) were prepared. The explosive selected was gelatine-dynamite I. The manager of the salt-mine and the Government district-inspector betook themselves on May 4th to the Zappendorf bore-hole, accompanied by two officials of the mine in charge of 5½ pounds of dynamite. The insulated copper-wires for the electric ignition having been duly set in place, the first attempt to cause a detonation in the bore-hole failed. It was assumed that the failure was due to a spoilt detonator, more especially as no difficulty was experienced in causing a second detonator to ignite above bank. The cylindrical galvanized iron receptacle in which the dynamite-cartridges were placed is described and figured; the space remaining vacant therein was stuffed with wadding to a depth of about 0·4 inch (1 centimetre). As the bottom cover seemed to sit loosely on the cartridge-filled cylinder, the manager, despite certain objections raised by those present, gave orders to solder it lightly. At the very moment when the man was applying the soldering-iron, the dynamite exploded, and four out of the five persons who stood immediately round were torn limb from limb; the fifth (the Government inspector) was so seriously injured that he died after a few hours' suffering in hospital. Several other persons, who had stepped a little aside before the explosion, were slightly injured.

Expert opinion (fortified by experiments, of which an account is given, made after the disaster) is in concurrence with the official report issued by the Mining Bureau of the West Halle district, in holding that the explosion was caused by the contact of the soldering-iron with the metallic cylinder. The heat from the former must have been conducted almost instantaneously through the thin metallic partition to the gelatine-dynamite, which is apt to decompose and explode at such a temperature as that which the soldering-iron had reached. The manager, who paid for his imprudence with his life, although quite right in stating that dynamite can be harmlessly burnt off while held in the hand, had overlooked the fact that this statement only holds good of small quantities of the explosive burning in an unconfined space, not of large quantities enclosed in a receptacle. L. L. B.

GRÉHANT FIRE-DAMP INDICATOR.

Note sur le Grisoumètre simplifié de M. le Professeur N. Gréhant. ANON. *Annales des Mines*, 1906, *series* 10, *vol. x.*, *pages* 570-573, *with* 1 *figure in the text.*

The fire-damp indicator devised by Prof. Gréhant, and first described by him in 1894, was, in its original form, somewhat cumbrous and needed very delicate handling, with the result that it was but little used in practice. But the instrument has been now so simplified as to make it very much more convenient to manipulate, and to render it more easily available for taking laboratory-samples from the atmosphere of fiery mines. In its present form, it consists of a cylindrical glass-bulb within which is soldered a platinum-spiral; by means proximately of two glass-tubes filled with mercury, and then, by gutta-percha covered copper-wires, the spiral receives the current flowing from a battery of ten accumulators. In the upper portion of the glass-bulb is a tap, by means of which the gas that is to be analysed can be turned into it; and into the lower portion of the bulb penetrates a long glass tube, graduated from the point of contact with the bulb, and communicating by means of india-rubber-tubing with a glass recipient (or reservoir) containing water, which can be raised or lowered by a rack-and-pulley arrangement. The bulb first described is itself immersed in a cylindrical recipient or jacket, through which water is kept continuously flowing, so as to maintain the temperature at a constant level throughout the experiment. The relation between the volume or capacity of a division of the graduated tube and that of the bulb having been determined, the bulb is filled with water, and the gas which forms the subject of analysis is introduced into it until the gas fills up the bulb as well as a suitable number of divisions of the graduated tube. Then the tap having been turned off, the movable reservoir is raised so that all the gas is forced back into the bulb, and the electric current is switched on until complete combustion of the methane formene [not hitherto mentioned in the original paper] has taken place—this implying about 400 passages of the current in 3 or 4 minutes. The operator waits for a few minutes, until the temperature in the bulb returns to its normal level; the gas is then brought back to atmospheric pressure, and the diminution in volume will indicate the percentage of contained fire-damp, on the assumption that this diminution is equivalent to twice the volume of methane contained in the mixture, in conformity with the equation expressing the combustion: $CH_4 + 4\,O = CO_2 + 2\,H_2O$. The size of the bulb and the graduations of the tube can be so arranged as to involve a reduction in volume of ten divisions of the graduated tube for a mixture containing only 1 per cent. of fire-damp; and this implies a sensitiveness amply warranting the use of the instrument in mining practice. It is suggested that a convenient and portable size of instrument is obtained by using a glass bulb of 2½ cubic inches capacity, with a tube so graduated that 50 divisions represent a volume of ¼ cubic inch. The operator must beware of introducing into the apparatus any inflammable mixture, the explosive combustion of which would undoubtedly shatter the bulb.

This indicator differs from Prof. H. Le Chatelier's instrument chiefly in that the latter indicates percentages of fire-damp by means of variations in pressure (the volume being always reduced to the same value); whereas the former keeps the pressure constant while varying the volume, and is perhaps more easily manipulated on that account by comparatively uneducated persons, such as those in whose hands the instrument would sometimes (at all events) be placed in mining practice. The sources of error due to the solubility of carbon dioxide in water, and to the difference of temperature between the

ambient atmosphere and the water-jacket, are not of sufficient importance in practice to vitiate the records yielded by the Gréhant indicator.

L. L. B.

FIRE-DAMP EXPLOSION AT THE LIÉVIN COLLIERIES, FRANCE.

Explosion de Grisou aux Mines de Liévin. ANON. *La Revue Noire*, 1907, *vol. x., pages* 43-45.

On January 28th, 1907, about 9 a.m., an explosion occurred in No. 3 pit of the Liévin collieries, whereby three persons lost their lives. They were engaged in perfecting the arrangments for conducting mine-gases from a disused portion of the workings in the François seam to an experimental gallery, which is in course of completion near No. 3 pit, and the nearest man was about 400 feet away from the François seam when the explosion took place. It may be noted, by the way, that the Liévin collieries have the reputation of being the most fiery of any in the Pas-de-Calais. At first, there seemed to be a reversal of the ventilation, but this almost immediately resumed its normal course; the noise and shock of the explosion, however, caused a momentary panic throughout the workings, and a crowd speedily assembled at the pit-head, fearing that a catastrophe had occurred on a scale similar to that of Courrières collieries. The great precautions habitually taken in these Liévin collieries: water-spraying, separate ventilation for each district, whitewashing of the walls of the roadways, etc., largely account for the restriction of the disaster to a comparatively limited area. The bodies of two of the victims (engineers) were found with wounds in the head and broken limbs, but practically unscorched; the third (an overman) was scorched from head to foot, yet his safety-lamp was intact, while those carried by the others were considerably damaged. Nevertheless, it seems probable that it was the overman's lamp that started the explosion. His body was found about 2,000 feet away from the two others; he appears to have gone on in front of the engineers in their tour of inspection, and, having met with fire-damp, it is probable that he precipitately withdrew his lamp, of which the regulating-screw was defective in such a way as to allow of the flame being blown upward (to the top of the gauze). On the other hand, experiments subsequently made with the very same lamp seem to point to the possibility that incomplete combustion of the fulminating-caps connected with the igniter leaves behind particles, the flame from which is quite capable of flashing through the double gauze of the lamp. It is noted that the excessive inflammability of these fulminating-caps is no new discovery, as similar results have been observed in the course of experiments carried out both in Great Britain and in Belgium.

L. L. B.

EXPLOSION AT THE DESDEMONA SALT-MINE, HANOVER.

Die Explosion auf dem Kaliwerk der Gewerkschaft Desdemona im Leinethal, Bergrevier Hannover. By — WIGAND. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., pages* 461-473, *with* 3 *figures in the text and* 1 *plate.*

The Desdemona mine lies midway between the Frisch Glück mine at Eime (where a disastrous fire-damp explosion occurred in 1904) on the north-west, and the Hohenzollern mine on the south—all three belonging to the Leine valley group of potassium-salt mines. The presence of inflammable gases in such mines has long been known, but the extent of the danger was not, at first, realized; and the Frisch Glück explosion was regarded as a quite

exceptional occurrence. Moreover, the view was widely held that there was a necessary connexion between the presence of anhydrite, etc., and the evolution of dangerous gases, and that these were not to be feared in the salt-beds themselves.

The strata in the district are highly disturbed; but, so far as can be ascertained, the three above-mentioned mines work the same potassium-salt horizon in the Zechstein (Permian) of the Leine valley. An account is given of the tectonic structure of the district, as also details of twelve bore-holes. Sinking operations begun at the Desdemona mine in October, 1901, were completed in 1905, when the shaft reached its present depth of 2,302 feet below the surface. There are four main levels, at the respective depths of 1,394, 1,558, 2,115, and 2,263 feet; the two uppermost form the upper, and the two lowermost the lower, division of the mine. Both divisions intercommunicate only by means of the shaft, and from that point onward are ventilated by entirely separate air-currents. It is not yet stated how many distinct beds of potassium-salt have been opened up at these levels. On the whole, the salt-beds dip like the rest of the strata, south-westward, and strike from south-east to north-west; but there are extraordinary variations, due to the disturbed stratigraphical conditions. There would seem to have been a mighty overthrust of the salt-beds and the overlying Bunter sandstone and Muschelkalk on to the Middle Bunter sandstone.

A description is given of the ventilating arrangements in the mine, from which we gather, among other particulars, that the brattice-cloths, nailed to wooden-frames and wedged up to the roof with wooden laths, were covered with a coating of fireproof paint, consisting of an intimate mixture of magnesium chloride and clay, which was renewed every week, and fulfilled (as the event proved) its purpose. Above bank a Capell fan was installed, with a guaranteed capacity of passing through 84,745 cubic feet of air per minute. At the time of the disaster, it is calculated that 8,475 cubic feet of air per minute arrived at the working-face in the 2,263 feet level, or about 565 cubic feet per man. On account of the high temperatures prevalent in the mine, the duration of the shifts was limited to 6 hours; and, in compliance with a Government ordinance of April 30th, 1906, measurements of the temperature were carried out at regular intervals, as indeed they had been at an earlier date at this particular mine in anticipation of the ordinance. Safety-lamps, which could only be unlocked with a special key, were in use at all the working-places; but the workpeople, who hardly knew what fire-damp was, had scant experience of the manipulation of safety-lamps or understanding of the purposes which they are intended to fulfil. It was the custom to drill a hole several feet in advance of the working-face, so as to ease off possible sudden outbursts of gas, as it was always assumed (as above-mentioned) that the presence of dangerous gases was connected with the country-rock and more especially with the anhydrite. For blasting or shot-firing, combined charges of dynamite and blasting-nitrate were used, and ignited by means of an ordinary fuse.

Despite the precautions observed in connexion with shot-firing and the other matters cited in the foregoing paragraph, an explosion took place on May 7th, 1906, which resulted in the death of four persons; two others were rendered unconscious, but were brought out scatheless. Four shots had been fired towards the end of the afternoon shift, and after a timed pause of 10 minutes, according to the account of these survivors, they proceeded to the working-face in order to see what had been the effect of the shots, when they were thrown to the ground by a violent blast of air. Springing to their feet

again, they relighted their lamps, which had been extinguished, and hastened towards the shaft, pursued by the smell of burning brattice-cloth, while the atmosphere of the roadway was full of inflammable gases. At the western cross-cut their lamps went out again, and they sat down, their further progress being barred by wreckage of brattice: shortly afterwards they lost consciousness. The work of the rescue-party was greatly hindered by heat and smoke, and more especially by the fact that electric lamps were not available, while the safety-lamps that were in use were continually going out. Three of the four dead bodies that were found were severely scorched, and brattice-cloths were in part carbonized: these had evidently smouldered, but had burnt without flame, and when the carbonized portions were subjected for several minutes to the flame of a spirit-lamp it was found impossible to re-ignite them.

Close investigation of the working-face showed that a large fissure (in reality, three parallel fissures) must have been met with, whence arose the outburst of gas. The rescue-party could find no trace of any dangerous gases remaining in the atmosphere of the workings, nor were any observed the next day on the occasion of the official investigation. The possible causes of the explosion are discussed in minute detail, and the conclusion is reached that the inflammable gases caught fire at the lamp of one of the victims, but exactly in what way will never be known.

In the hard salt (hard rock salt?), as distinct from carnallite and ordinary rock-salt, are cavities, of generally conical form but varying dimensions, in which are often occluded gases smelling of petroleum. In an exceptionally-large cavity, which assumes rather the tubular form, measuring 15½ feet in length and averaging 3¼ feet in diameter, the smooth walls were sweating an oil that smelt like petroleum a few days after the cavity had been opened up. Similarly, oil sweats out into some drill-holes in the hard salt to such an extent that it has been possible to collect sample bottlefuls and submit the contents to analysis and distillation. The crude oil is shown to have the following volumetric composition: benzine, 14·5 per cent.; petroleum, 58·5; paraffin, 21; and tar, 6. As to the gases occluded in the hard salt, the inference is fairly obvious, that they are not pit-gases in the ordinary sense of the word, but merely the distillation-products of the above-described oil. Although no traces of oil have ever been found in the carnallite, it is beyond question that gases are occasionally occluded in that mineral. L. L. B.

EXPLOSIONS IN PRUSSIAN COLLIERIES DURING THE YEAR 1905.

Mittheilungen über einige der bemerkenswerthesten Explosionen beim preussischen Steinkohlenbergbau im Jahre 1905. [OFFICIAL.] *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., pages* 421-438, *with* 8 *figures in the text and* 3 *plates.*

At 10·30 a.m. on June 28th, 1905, a fire-damp explosion took place in No. 5 western division of No. 6 level, in the workings of the Emil seam at the Holland colliery, district of Wattenscheid. The seam is 4½ feet thick, lies 341 feet below the Laura or Main seam, belonging consequently to the Upper Bituminous coal-group, and gives off extremely little gas. The dip is variable, from 10 to 50 degrees northward, but decreases on the whole as the depth from the surface increases. A description is given of the conditions of ventilation in that part of the workings which was the scene of the disaster, and it is pointed out that neither the overmen nor the officials who inspected the place 2 hours or so before the occurrence, noticed the slightest trace of fire-damp in the atmosphere. Of the five persons at work there four

were killed on the spot, and the only survivor (an apprentice hewer) succumbed to his injuries a few days later. According to his death-bed account of the catastrophe, two sharp reports were followed by the extinction of his safety-lamp, and he observed no flame; he felt his lips, face, and hands suddenly swollen up, and crawled on his hands and knees to the cross-cut; he heard the hewer, whose duty it was to look after the Pelzer fan at that point, moaning, but had just the strength to throw himself into the water-tank and then lost consciousness. Others, who were at the cross-cut in the Bismarck seam, heard a rolling as of thunder, but saw no flame: their safety-lamps were suddenly extinguished, and they were hurled back a few paces. After rescuing the apprentice-hewer, and noting that the fan was still at work, although the air-conduits were in part destroyed, they had to beat a retreat, as the after-damp was meanwhile penetrating even into the workings of the Bismarck seam. In the course of 36 hours, the bodies of the dead, who were found to have suffered severe burns, were recovered; it was shown that death must have been almost instantaneous, and that the men fell where they stood. Two of the safety-lamps used by the victims were found much damaged; but they were both locked, and the igniters were in perfect order. The continued evolution of fire-damp prevented a thorough inspection of the scene of the disaster until July 19th, three weeks later. It was then seen that the timbering had sustained but little damage, but that some 130 feet of suction air-tubing had been rendered useless. There was no trace of coke-incrustations at any point, and the conclusion is reached that coal-dust played no part in the explosion. This seems to have been due to the sudden outburst of a gas-blower, which caught fire at the overman's safety-lamp (the wire-gauze of which, both inner and outer, was damaged). The shape of the holes in the gauze suggests that it had received an accidental blow from a pick.

In the Wattenscheid district again, an explosion took place at 8·30 p.m. on October 31st, 1905, at the Centrum colliery, in the deep-level workings (No. 6) in the Franziska seam. Four men were badly burnt, and two of them succumbed to their injuries within 48 hours. The Franziska seam has a thickness of 7½ feet (inclusive of partings), and dips 47 degrees southward. Water-spraying appliances were in regular use, and the deputy who inspected the workings in that seam at 7·15 p.m., reported that no coal-dust was discernible anywhere. There had been some slight falls of stone, which occasionally interfered with the loading-out of the coal; consequently, in order to get rid of some of the bigger stones, two shots had been fired (although this had been distinctly forbidden) apparently with dynamite-cartridges, and the second shot started the explosion. A great flame burst out from the seam into the cross-cut, and afterwards beads and incrustations of coke were found on the timbering in the vicinity, although the floor was everywhere damp and in parts actually wet. The official view is that this was a coal-dust explosion pure and simple; fire-damp can hardly have played a part here, taking all the circumstances into consideration, and, in fact, no fire-damp was observed in the workings after the disaster. The shot-firer, with reprehensible carelessness, had ignited a dynamite-cartridge amid loose stone, and had neglected to render the coal-dust harmless by spraying it over with water before he fired the shot.

On November 17th, 1905, at 7 p.m., an explosion of fire-damp took place in the Henry pit of the De Wendel colliery, in the mining district of Hamm, whereby two hewers sustained more or less severe burns. The colliery is still in course of being opened up, and is provided with one haulage or winding-shaft and one ventilation-shaft. From the lowest of the two levels so far driven (2,395 feet), west of the northern main cross-cut, and about 700 feet

distant from the main shaft, a vertical staple was being driven, which had reached a height of 262 feet on the day of the accident: it was timbered, and divided into three segments for travelling, carriage of timber, and rolling down stone, etc. In the previous shift, the floor of the Anna coal-seam, 2½ feet thick, and dipping 9 degrees northward, had been laid bare; and a compressed-air system of conduits, providing the power for machine-drilling, and available also (if need were) for increasing the ventilation, had been erected in the staple. On account of the laying-bare of the Anna seam, instructions had been given to make an examination for fire-damp every ½ hour, and to bring the ventilating air-conduits closer up. In the course of scaffolding work, a man was holding a safety-lamp near the roof when fire-damp appeared in the gauze, and the man was so greatly scared as to drop the lamp; as it fell, the flame flashed through the double wire-gauze, and the fire-damp was exploded with a loud report. The official investigation showed subsequently that there had been no tampering with the lamp-locks; that coal-dust bore no share in the explosion; and that the volume of fire-damp involved was comparatively small, as the dynamic effects of the explosion were hardly noticeable, and only two out of the three men within reach sustained any injury. If the man who held up the safety-lamp had shown more foresight and presence of mind, the accident would probably not have happened at all.

About 11 p.m. on December 5th, 1905, a fire-damp explosion occurred *above* bank at the pit-head of the Werne colliery, also in the Hamm mining district, with the result that one person was severely injured and seven were slightly injured. This colliery had only been at work for a short time, yielding a daily output of about 1,000 tons and employing 1,600 workpeople. There are two shafts, each 19 feet in diameter, some 270 feet apart: one being used for winding, and the other for ventilation. The eastern district of the colliery worked twelve seams, all dipping very steeply, much disturbed, and extremely fiery; this district accounted for two-thirds of the entire output of the colliery. There is a causal connexion between the explosion and a pit-fire, which broke out on November 26th, 1905, in section 2 of the eastern district, and had assumed such an extension as to necessitate the stopping-off of the entire district. The origin of the fire was uncertain: the officials held, however, that it was, at all events, not due to spontaneous combustion, and took measures directed to its speedy extinction. Encouraged by the samples taken from a tube inserted in one of the masonry-dams (showing that no gases of combustion were remaining in the area of conflagration), and being anxious to replenish the sorely-diminished stock of bituminous coal, the officials caused a large opening to be made in the dam at 9 a.m. on the day of the explosion. Fire-damp issued in considerable volume, but was sufficiently diluted by the powerful ventilating-currents flowing in from north and south. The second dam, for safety's sake, was only to be opened up late in the evening, after the termination of the afternoon shift; this was done about 10·45 p.m., and then fire-damp streamed out in enormous quantities. Meanwhile, something went wrong with one of the motors that were driving the ventilators, and this had just been set right when the explosion took place above bank. A loud report was heard, and a sheet of flame shot out from the ventilator, while the floor of the engine-room rocked and the occupants were hurled about in all directions. The ventilators were smashed to fragments, their foundations were destroyed, though the two motors remained in place all but undamaged. The structures at the head of No. 1 shaft collapsed, windows in neighbouring buildings were shattered, and roofs and walls were damaged by flying parts of machinery. Below bank, the effects of the explosion were unimportant in

comparison, although some considerable damage was done. For many weeks thereafter haulage was entirely at a standstill, the remaining workable districts of the colliery yielding but little more coal than was sufficient for its own needs. An unprejudiced explanation of the cause of the explosion is not forthcoming: it can only be said, without fear of contradiction, that it started in the central engine-room, either in the ventilator itself or in its immediate neighbourhood.

Four men perished and four others were injured, as the result of an explosion which took place at 9 p.m., on December 7th, 1905, in the Eschweiler-Reserve colliery at Nothberg, in the mining district of Düren. Official enquiry has failed to elucidate the cause of the disaster, but it is supposed that a small blower of fire-damp (the presence of which had not been previously indicated anywhere in that part of the workings) was ignited at a naked light as the men were resuming work after an interval. Coal-dust evidently played a part in the disaster. A shot had been fired, probably with gelatine-dynamite; a foot or two away from the drill-hole a safety-lamp was subsequently found, with its glass cylinder smashed, and a little tin-box containing matches. No fire-damp was ascertainable as present after the catastrophe.

L. L. B.

EXPLOSION AT THE REDEN COLLIERY, NEAR SAARBRÜCKEN, GERMANY.

Die Explosion auf der königlichen Steinkohlengrube Reden bei Saarbrücken am 28. Januar 1907. By — Einer. *Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate*, 1907, *vol.* lv., *pages* 167-190, *with* 3 *figures in the text and* 1 *plate.*

On Monday, January 28th, 1907, shortly after 7 a.m., a disastrous fire-damp and coal-dust explosion took place in the Government colliery at Reden, wreaking greatest havoc in the remote Nos. 14 and 15 districts of the Thiele seam. No less than 149 persons were killed on the spot, one man died later in hospital from the results of carbon monoxide poisoning, and 37 persons suffered more or less injury from burns, from the dynamic effect of the explosion, or from breathing in after-damp. The Thiele seam is the third, counting from the top, in the bituminous coal-group, and is being actively worked; while the two uppermost seams (the Stolberg and the Carlowitz) have not as yet been touched in the Reden concession. This Thiele seam is about 6½ feet thick, dips 14 degrees north-north-westward, and has, apart from a few insignificant local disturbances, a very regular lie. It yields a coking coal of good quality, and contains 38·35 per cent. of volatile matter (calculated from ash-free material). But little shot-firing is needed in the course of getting the mineral; roof and floor alike consist of fairly compact and tough shales. The pressure or creep that ensues on working-out of the coal is considerable. The invariable method of working is longwall, and the average daily output of the two districts chiefly affected amounted to 420 tons.

The seam is not especially fiery: a sample of pit-gas, taken in January, 1907, not very long before the explosion, yielded barely ¼ per cent. of methane. At no time in the colliery did the percentage of methane exceed 0·6 per cent., and the evolution of gas may be reckoned at 530 cubic feet per ton of output. It is true that, in the course of forewinning operations, there was now and again an incursion of fairly large volumes of gas; but, in the weeks preceding the disaster, practically no fire-damp had been observed, either at the working-face or in the forewinning. Such gas as did penetrate into the workings is believed to have streamed in through fissures in the roof from the Carlowitz

seam (20 feet above the Thiele seam) which is known, and proportionately feared, throughout the Saare coal-field as extremely fiery. Be this as it may, no explosions had as yet taken place in the Reden bituminous coal-field. Daily examination of the workings for pit-gas was carried out, and the results thereof were reported above bank before the men went down. But eye-witnesses aver that, on the morning of the disaster, the two overmen, whose duty it was to conduct this examination in the particular districts involved, started work so late, that they could not possibly have complied with the strict letter of the regulations and have traversed every foot of the workings. However, the two overmen reported all workings in their respective districts as quite free from fire-damp before the commencement of the morning shift, and they both perished in the explosion. The barometer which, on Saturday, January 26th, stood at 29·33 inches (745 millimetres), rose about noon on Sunday, the 27th, to 29·53 inches (750 millimetres), at which height it remained up to the time of the disaster. Three hours later (10 a.m. on the 28th), it fell to 29·29 inches (744 millimetres), and a deep depression set in during the night of the 28th to the 29th, a minimum of 28·78 inches (731 millimetres) being registered on Wednesday, the 30th. The normal height of the barometer calculated at sea-level, is 28·86 inches (733 millimetres) for the altitude of Reden.

There is no question about the dustiness of the Thiele seam—and the dust which it makes is excessively fine. There is nowhere enough natural moisture in the pit to render this dust innocuous; and consequently, in accordance with the regulations, a water-spraying system is in constant activity, except on Sundays and holidays. Ventilation is effected by means of a Pelzer fan, 10½ feet in diameter, normally capable of passing through more than 77,680 cubic feet of air per minute; this amount, without any undue strain on the installation, can be raised to 106,000 cubic feet per minute, an increase which was actually found practicable immediately after the explosion. The fan is driven by a horizontal single-cylinder engine, of 80 effective horsepower. The water-gauge diagram, reproduced by the author, showing the extraordinarily sudden steepening of the curve, constitutes a striking record of the effect of the explosion. Details are given of the system of air-splitting, and it is stated that the temperature of the air-currents after passing through the mine averaged 78·8° Fahr. All the safety-lamps used at the working-face were benzine single-gauze; double-gauze lamps were occasionally used in forewinning operations. The lamps were lighted from inside (without unlocking) by means of a friction-igniter, which has always given satisfaction; the general upkeep and cleansing of the lamps was also satisfactory, and an examination of those used by the victims of the disaster revealed nothing that would point to wilful damage, forcible opening, etc. The explosives used for shot-firing were partly wetterdynamit and partly kohlenkarbonit. It had never been found necessary, either on the part of the colliery-officials or on that of the Government inspectors, to restrict the firing of shots in any way.

When the disaster occurred, the shift had hardly settled down to work; many of the miners had not reached their appointed places, and the pit-horses were just being hitched on to the tubs. About 7·15 a.m., a man reported that a violent rush of air from the main cross-cut had knocked him down, and it was evident that something unusual had happened in the workings, although no sign of it was observable above bank. All the officials went down the pit to the rescue, while messages were sent for doctors, ambulances, and parties with rescue-appliances. The after-damp, which is described as

rolling through the workings in the form of a greenish-grey mist, hampered considerably the efforts of the first-comers and drove them from one roadway to another. The survivors who were nearest to the scene of the explosion, claim to have heard two distinct reports, which became merged into one in the hearing of those farther away. A description is given of the condition in which some of the dead bodies were found, showing that several of the victims perished from asphyxiation by poisonous gases, but the great majority from burns and injuries sustained by falls of rock. The Draeger air-breathing apparatus seems to have been successfully used by the parties engaged in exploring the workings for possible survivors; as also the oxygen-cylinder, in the case of an overman who suddenly collapsed on his return from an inspection of his own district (to ascertain whether everyone had been safely withdrawn), and was brought back to consciousness in the course of 10 minutes by means of the insufflation of oxygen.

False alarms of fire occasioned a suspension of the rescue-operations, with a consequent delay of fully 24 hours. Operations were actively resumed on January 29th, and all the bodies of the victims, with the exception of four buried under an enormous fall of rock, were brought to bank the next day. Even these four bodies were recovered, after a week's strenuous exertion directed to the removal of the huge mass of fallen rock.

The author, in his capacity of Government district-inspector, examined the mine thoroughly, and gives a detailed account of his observations. He concludes that the disaster was in the main a coal-dust explosion, fire-damp playing only a secondary part therein. Coke-incrustations were observed in nearly every portion of the workings affected by the explosion. All endeavours to ascertain beyond question the actual cause of this catastrophe have remained fruitless; in a series of closely-reasoned paragraphs, the author dismisses one plausible supposition after another.

A few days after the occurrence, the Royal Mining Bureau at Saarbrücken issued an ordinance providing for the spraying of all dry coal-dust before the commencement of the morning shift, especially after Sundays and holidays; prescribing also a stricter system of selection of those who are to be entrusted with the supervision of both spraying and ventilation; and recommending an abstention from alcohol for 6 hours before entering on their duties, on the part of those officials and men who undertake the Sunday night-watch.

Other fresh precautions have been taken at the Reden colliery, including the use of double-gauze instead of single-gauze safety-lamps; and the Prussian Minister for Trade and Industry has nominated a commission to enquire generally into the conditions as regards safety of the Government collieries in the Saare coal-field, with power to suggest any changes that may seem desirable.

L. L. B.

FIRE IN THE BORUSSIA COLLIERY, DORTMUND, GERMANY.

Der Grubenbrand auf der Zeche Borussia bei Dortmund am 10. Juli 1905. [OFFICIAL.] *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv., pages* 642-670, *with* 11 *figures in the text and* 5 *plates.*

At the beginning of the morning-shift on July 10th, 1905, a haulier knocked over a hanging petroleum-lamp, which lighted the pit-eye at the fifth level in the winding-shaft of the Borussia colliery. Thereby a heap of timber was set alight; in a very short space of time the fire struck across the shaft, and the clouds of smoke that quickly filled the workings to the

north of it caused the death by suffocation of 39 miners out of the 81 who were at work therein. It was not until the beginning of May in the following year that all the bodies of the dead were recovered, as the fire had spread to a neighbouring seam, and its extinction was a necessary preliminary to the recovery of the bodies. The manager of the mine was prosecuted on the plea of manslaughter by negligence, and for having contravened two of the Government mining regulations, but was eventually acquitted on both counts.

No less than fifteen seams are worked in the Borussia colliery, and the daily output at the time of the disaster averaged 570 tons. The winding-shaft, 1,902 feet in depth, was of quadrangular cross-section built in masonry down to 115 feet, and thence downward lined with timber; it was entirely destroyed by the fire. The author notes, by the way, that this shaft had just been completed, when the Government ordinance of March 28th, 1902, came into force, prohibiting the timber-lining of shafts for the future. A special water-spraying arrangement kept up a sufficient dampness in the shaft, to comply with the mining regulations, which decree this where naked lights are used. As in all timber-lined shafts, continual repairs were found necessary; and the visits of Government inspectors were frequent. Three such visits of inspection had already taken place in 1905, the last before the disaster being on May 28th; apart from these special inspections of the shaft, there had been no less than twenty-two general inspections of the mine during the first six and a half months of that year.

The general testimony of the witnesses examined at the enquiry concurs in regard to the continually damp condition of the pit-eye at No. 5 level, and to the consequent absence of coal-dust there. The base of the hanging-lamp which started the conflagration, cannot have been more than 5 feet 10 or 11 inches above the floor: it was enclosed in a sort of quadrangular metallic lantern, the glazed openings in which had been shattered about a month before the disaster. Below it, on the morning of July 10th, 1905, were stacked about 100 pieces of pit-timber, which had been lying there since the night of the 7th to the 8th, and were to be distributed among the workings in the course of the morning-shift. The hauliers who were working at the pit-eye, in order to allow free play for the tubs, found it necessary to toss over to the rear part of the stack some of the props, and one of these knocked over the lamp: the petroleum flowing out of the lamp-reservoir immediately set the stack aflame. The hauliers made some efforts to extinguish the fire, to which curiously enough, they attached no great importance, in the intervals of their work. Presently, the former deputy-manager appeared on the scene, and reproaching the men for their negligence, caused more active measures to be taken. But these proved futile for various reasons, the chief being that the fire had already gained too great a hold. Then, through the mistake of a newly-appointed overman, the wrong brattice-doors were opened, with the result of driving the smoke and gases of combustion through a portion of the workings, and of causing erroneous conclusions to be formed above bank as to the course that the ventilation was taking.

A description is given of the various unsuccessful attempts to rescue the men who were unable to flee in time, and also of the final recovery in the night of May 1st to May 2nd, 1906, of the twenty-five remaining bodies.

In the course of the judicial proceedings above-mentioned, it was shown that water-hydrants and hose were duly available in the immediate neighbourhood of the scene of the fire; but, owing in some respect to flurry and forgetfulness on the part of the pitmen who should have used those appliances, they were not timeously turned to account, as they might have been.

As a consequence of the disaster, the Royal Mining Bureau of Dortmund issued an ordinance, which came into force on May 1st, 1906, forbidding the use of naked lights in places which are built otherwise than of masonry or constructional steel, and wherein combustible material of any kind is stacked even temporarily. Where such lights are permitted, they must be enclosed within glass which is shielded from any possible breakage, and must not be fed with petroleum, or spirit, or any similar easily-vaporized fluid. The use of portable electric lamps burning *in vacuo* is permissible in downcast shafts, at the pit-eyes communicating with them, and in the immediately neighbouring engine-rooms. Apart from the places specified in the ordinance safety-lamps alone are permissible. L. L. B.

CHOKE-DAMP DISASTER IN AN UPPER SILESIAN COLLIERY.

Tödliche Verunglückung dreier Personen in matten Wettern im Ostfelde des königlichen Steinkohlenbergwerks "König" bei Königshütte O.-S. By — STEINHOFF. *Zeitschrift für das Berg-, Hutten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv.*, *Abhandlungen*, *pages* 298-299 *and* 1 *plate*.

This accident occurred on November 12th, 1905, in the eastern district of the State colliery of König, at Königshütte, and resulted in the death of three persons. For more than two years a portion of the workings in the Gerhard seam (18 feet thick) had been shut off by strong masonry-dams on account of pit-fires, and an endeavour was now made to ventilate that area. Chemical analysis of samples of the atmosphere taken from behind the stoppings showed it to contain, in volumetric percentages, 0·0023 of carbon monoxide and 4·874 of carbon dioxide. On the termination of the night-shift of Saturday, November 11th, provision was made for opening up successively two stoppings and drawing the gases out by means of the ventilator at the Bittkow shaft. At first all went well, but the overman to whom the arrangements were entrusted noticed that the ventilating current travelled very slowly into the old area of conflagration, and inferred that there was some obstacle, such as a brattice, to its passage. He thereupon ordered the two men who were working with him to search in the direction of the goaf, one of them being provided with a Giersberg apparatus and the other with a Shamrock Pneumatophore of the old type. It may be mentioned that both appliances had been overhauled shortly before and declared to be in proper condition, and that the men were thoroughly familiar with their manipulation. A third man stood ready with a reserve Pneumatophore, so as to be able to render immediate assistance if required. The two first-mentioned men went about 300 feet within the second stopping, when one suddenly grasped the other's arm, and, evidently feeling unwell, signed to him to turn back. As they did so, he stumbled on the partly broken-up floor and fell about 60 feet distant from the second stopping, with the probable result that the mouthpiece of the Pneumatophore slipped from his face. He had fallen among a lot of scattered timber, and being unable to rise immediately, shouted for help, whereby he breathed the deadly gases in full measure. His companion, who had heard the cry and seen him fall, rushed up to the stopping to get help to carry him out, as he felt too excited and too exhausted to do so unaided. The overman outside, without pausing to put on a Pneumatophore, ran behind the stopping, but had hardly gone 10 feet when he was struck down by the poisonous gases. Then a fourth man, under similar circumstances, sprang forward to the assistance of the victims, only to collapse in turn. Four other pitmen successively braved the dangerous atmosphere, col-

lapsing one after another, but were brought out by the first man who had run for help, as he had meanwhile somewhat recovered his strength. He made a heroic attempt to save the other victims, but found this physically impossible. Rescue-parties called up by telephone brought two men out (one of whom was the overman), but all endeavours at resuscitation unfortunately failed, and the body of the man who first stumbled and fell was not got out until later.

The breathing-appliances used by the two men who first went into the gas-laden area were subsequently condemned as untrustworthy; but it was held that the disaster would never have occurred, if the overman entrusted with the arrangements had carried them out in strict accordance with his instructions, and had not concerned himself with the inevitable slowness of the process of ventilation. Large volumes of a heavy gas such as carbon dioxide are always slow to move.

BOILER-ACCIDENTS IN FRANCE DURING 1905.

Bulletin des Accidents d'Appareils à Vapeur survenus pendant l'Année 1905. [OFFICIAL.] *Annales des Mines*, 1906, *series* 10, *vol. x.*, *pages* 586-598.

Among the 29 accidents recorded in France during the above-mentioned year, whereby 14 persons lost their lives and 33 others were seriously injured, none is stated to have occurred in or about a mine. One accident, which happened at a foundry at Tarnos, in the Landes, on July 28th, to a cylindrical boiler, resulted in slight injury to three workmen and considerable damage to property. The cause was evidently superheating, probably, but not certainly, occasioned by insufficient water-feed. Two accidents occurred at electric-power stations; one to a De Naeyer water-tube boiler, possibly due to the inadequacy of the precautions taken against incrustation; the other to a Niclausse water-tube boiler, due to superheating apparently occasioned by insufficient water-feed.

Eleven of the accidents are assignable to original defects in the structure or setting-up of the boiler, eight to defective upkeep, thirteen to faulty usage, and five to undefined causes. Thus thirty-seven causes are found for twenty-nine accidents, because in no less than five instances the accident was due to two several causes, and in one instance to as many as four. Non-tubular boilers were concerned in four cases, fire-tube boilers in eleven cases (which involved most of the recorded injury to life and limb), and water-tube boilers in six cases. L. L. B.

ACCIDENTS IN CONNECTION WITH ELECTRICAL INSTALLATIONS IN PRUSSIAN MINES DURING 1905.

Unfälle in elektrischen Betrieben der Bergwerke Preussens im Jahre 1905. [OFFICIAL.] *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1906, *vol. liv.*, *pages* 439-448, *with* 3 *figures in the text.*

At the Rheinpreussen colliery in the Düren district, a man was instantaneously killed on January 13th, 1905, through meddling with a switchboard, from the hinder or rear part of which he had torn away the protecting cover, in the apparent endeavour to determine the cause of a momentary stoppage in the working of a high-tension triphase motor. It is evident that, in doing this, he must have touched a naked live wire.

At the Dechen colliery, in the mining district of Neunkirchen, an electric circular saw is worked by a current, transformed down to 220 volts from the tension of 5,000 volts at which it starts from the power-station at the neigh-

bouring Heinitz colliery. The wires are carried from the transformer-room past the coal-washery at the Dechen colliery. At the very summit of the stairway of this coal-washery is a window for admitting the air, and from this window the wires are at least 2 feet distant; and therefore no one leaning out of the window could come into merely accidental contact with them. It would seem that on February 2nd, 1905, a haulier ran up to this window, opened it, and leaning forward snatched at the wires. He was standing on an iron stair, was shod with iron-nailed and damp boots, and thus made a short circuit between the wire and earth. All efforts to bring him back to life proved futile. Since that occurrence the window has been screwed up.

A fatal accident which happened on August 15th, 1905, at the Ver. Constantin-der-Grosse pit, in the Nord-Bochum district, shows that in damp mines continuous currents at a tension of only 220 volts are dangerous. An apprentice-hewer, officiously pushing forward to help in the uncoupling of a truck from an electric locomotive in the roadway of No. 1 level, attempted to squeeze past the locomotive, bending forward with his hands upon it, and touched a contact-button with his face, thus completing the circuit. His body was damp with sweat, and the floor on which he was standing was drenched with moisture. It is thought that, under other circumstances, the tension would have hardly been sufficient to kill the unfortunate youth.

At the Deutscher Kaiser colliery, in the Duisburg district, on Christmas Eve, 1905, a man was killed by accidentally grasping the wires through which a current passes, at a tension of 550 volts, for working a coke-oven discharging-machine. He was watching the preparatory operation of raising the oven-doors from a staging close to the machine, when, probably in craning forward to look at the farther side of the oven, he lost his balance, and involuntarily grasped the wires through one of the openings in the screen erected to protect the wires from accidental contacts. The current having been switched off, he fell to the ground, but all attempts at resuscitation proved unavailing.

Two men employed at the electrical installation of a colliery at Linden in the Hattingen district, were killed on July 27th, 1905, in the dinner-hour, by touching the naked clips of a cable which linked up the colliery-installation with the central high-tension station at Essen. As it was proposed to lay another (but temporary) cable to link up with Essen, it is assumed that they were engaged in ascertaining the most suitable way of laying it under the circumstances, but unaccountably forgot that the Essen line was never switched off, although the motors at the colliery itself were switched off.

At the Neuhof zinc-mine in the Tarnowitz district, a locksmith, who was helping a man to carry a naked wire along the roof of a building in the immediate vicinity of an insulated high-tension system, was holding the free end of the wire ready for attachment to a porcelain insulator when he came into contact with the high-tension cable, and was mortally injured. Evidently, the insulation of the high-tension cable, which had been subjected for two years to all the stress of weather, was defective; moreover, the roof, covered with bituminized sheeting, was wet from recent showers, and thus played the part of a conductor. Contrary to regulations, the man was unprovided with indiarubber gloves, and he should have had an indiarubber mat to stand on. Adequate inspection and measurement of the insulation (although the latter is not expressly prescribed) would have revealed its defective condition.

At the Kaiserstuhl I. colliery, in the Dortmund II. mining district, a man who was about to do something to an amperometer, forgot to take out certain safety-fuses from the distributing-board, by which he would have cut off from a switch-lever the current passing at a tension of 2,000 volts to the

motor. He grasped the lever with his bare hand, and was instantaneously killed by the entire current passing through his body.

A man had started to let down an arc-lamp, one of two that were not burning properly and were therefore being examined, at the Siegmundshall potassium-salt mine, Wunstorf, district of Hanover, on November 16th, 1905; but he had barely touched the lowering cable when he fell lifeless to the ground. A high-tension system (alternating current, 500 volts) for power-purposes is carried along parallel with the arc-lamp wires at a distance of 2¼ feet below them. It was afterwards ascertained that the lamp-wires, heavily laden with hoar frost and snow, had so bent under the weight as to come into contact with the high-tension wires; and the insulation of the former wires was not sufficient to prevent the diversion of the current from the latter to the lamp and the lowering cable connected with it.

The foregoing are fairly typical examples, but an account is given of thirteen other accidents, only one of which, however, resulted fatally. Some of them appear to have been due to sheer carelessness or forgetfulness, others to neglect of necessary precautions; but few seem to have been really unavoidable. L. L. B.

ACCIDENTS IN CONNECTION WITH ELECTRIC APPLIANCES AT PRUSSIAN MINES DURING THE YEAR 1906.

Unfälle in elektrischen Betrieben auf den Bergwerken Preussens im Jahre 1906. [OFFICIAL.] *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate, 1907, vol. lv., pages* 311-323, *with* 2 *figures in the text and* 1 *plate.*

Of the twenty-nine accidents described in this paper, the following are among the most serious:—

A mason, who had some work to do in the coal-picking department of the Gräfin Laura colliery at Chorzow, in the Königshütte mining district, carelessly touched, despite the most explicit warnings, some wires (conveying current at 500 volts) which had been laid bare in order to make fresh connections to them, and he was discovered hanging to the wires, a lifeless corpse.

On March 24th, 1906, a fatal accident occurred in connection with a new electric power-plant, at the coke-ovens attached to the Deutscher Kaiser colliery, in the Duisburg mines-inspection district. On attempting to switch on a high-tension current after the dinner-hour, the man in charge, momentarily startled by the explosive violence with which an arc-like spark made its appearance, involuntarily made contact with his bare right hand, and was struck dead instantly. "Super-tension phenomena," producing sparks with explosive violence, are likely enough to occur when several motors are switched on again, after a pause such as that of the dinner-hour. In this case, a few days after the fatality, super-tension was repeatedly observed, until a defect in a cable had been set right.

In the course of tarring a roof at the Cons. Trautscholdsegen colliery, in the South Kattowitz Mines-inspection district, on May 11th, 1906, a workman touched a naked wire conveying current at 500 volts; it is supposed that he slipped, and involuntarily caught at the wire in order to recover his balance.

At the Germania I colliery, in the third Dortmund mines-inspection district, a youth who, after eight days' apprenticeship, was engaged in polishing up a 1,800-kilowatt generator which was at rest, clambered, for reasons best known to himself, down into the flywheel pit, and, in attempting to get out again, touched a spot in one of the continuous-current cables where the insulation was afterwards shown to be defective, and so met his death.

At the Royal Maybach colliery, in the Eastern Saarbrücken mines-inspection district; at the Kostuchna colliery, in the South Kattowitz mines-inspection district; at the Wansleben salt-mine, in the Western Halle district; at the Shamrock I/II colliery, in the Herne district; and at the Radzionkau colliery, in the Tarnowitz district, fatalities occurred which were in every case due to carelessness and wilful disregard of the regulations on the part of the victims. To the same cause must be assigned at least ten of the non-fatal accidents described. Defective insulation would account for three other non-fatal accidents; as also for the fatality which overtook a man who was cleaning a boiler at the Ver. Hagenbeck colliery, in the South Essen district. He was using a portable electric lamp, supplied from the central station of the colliery by means of an alternating current at 110 volts; the fatal effect of the electric current was enhanced by the circumstance that the victim, who was very corpulent, was sweating a good deal and sitting on an iron boiler-tube. The fatality shows the necessity of perfect insulation of the handles of such lamps, as also that all external metallic parts (such as the protective gauze) should be set on that insulated handle or grip.

L. L. B.

II.—REPORT OF THE CORRESPONDING SOCIETIES' COMMITTEE AND OF THE CONFERENCE OF DELEGATES OF CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, LEICESTER MEETING, 1907.*

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The following Corresponding Societies nominated delegates to represent them at the Conference:—The Institution of Mining Engineers, Mr. J. A. Longden; Manchester Geological and Mining Society, Mr. William Watts; Midland Counties Institution of Engineers, Mr. J. A. Longden; and The North of England Institute of Mining and Mechanical Engineers, Rev. G. M. Capell.

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First Meeting, August 1, 1907.

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The CHAIRMAN delivered an address on "The Advancement of Geographical Science by Local Scientific Societies"; and the Rev. R. ASHINGTON BULLEN (South-Eastern Union of Scientific Societies) spoke on the advisability of appointing a committee for the photographic survey of ancient remains in the British Islands.

After discussion, it was resolved that the following resolution, proposed by Mr. Jerome Harrison, should be sent to the Committee of Recommendations for transmission to the Council of the Association, namely:—That it is advisable (1) to obtain information as to the present state of things in Britain in connection with photo-survey work; (2) to publish instructions or give advice for the execution of a scientific photographic survey; and (3) to endeavour to found, or promote, a photographic record of the town and district in which the British Association holds its annual meeting.

The Report of the Corresponding Societies Committee was read by the SECRETARY, and it was resolved to apply for a grant of £25.

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Second Meeting, August 6.

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* *Report of the Seventy-seventh Meeting of the British Association for the Advancement of Science, Leicester, August, 1907*, 1908, page 29.

Mr. C. O. Bartrum (Hampstead Scientific Society) reported that, as a result of Dr. Mill's suggestion at the last year's conference, his society had asked the London County Council for a site on the summit of Hampstead Hill for the establishment of a meteorological station; that the Council had granted the use of a site, and that by next year it was likely that the station would be in working order.

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Research-Committees appointed by the General Committee at the Leicester Meeting: August, 1907.*

1.—Receiving Grants of Money.

Subject for Investigation or Purpose.	Members of the Committee.	Grants.
		£ s. d.
Seismological observations	*Chairman.*—Prof. H. H. Turner. *Secretary.*—Dr. J. Milne. Lord Kelvin, Dr. T. G. Bonney, Mr. C. V. Boys, Sir George Darwin, Mr. Horace Darwin, Major L. Darwin, Prof. J. A. Ewing, Mr. M. H. Gray, Dr. R. T. Glazebrook, Prof. J. W. Judd, Prof C. G. Knott, Prof. R. Meldola, Mr. R. D. Oldham, Prof. J. Perry, Mr. W. E. Plummer, Prof. J. H. Poynting, Mr. Clement Reid and Mr. Nelson Richardson.	40 0 0
To co-operate with the Royal Meteorological Society in the investigation of the upper atmosphere by means of kites.	*Chairman.*—Dr. W. N. Shaw. *Secretary.*—Mr. W. H. Dines. Mr. D. Archibald, Mr. C Vernon Boys, Dr. R. T. Glazebrook. Dr. H. R. Mill, Dr. A. Schuster, and Dr. W. Watson.	25 0 0
To investigate the erratic blocks of the British Isles, and to take measures for their preservation.	*Chairman.*—Prof. P. F. Kendall. *Secretary.*—Dr. A. R. Dwerryhouse. Dr. T. G. Bonney, Mr. F. M. Burton, Mr. F. W. Harmer, Rev. S. N. Harrison, Dr. J. Horne, Mr. J. Lomas, Prof. W. J. Sollas, Mr. J. W. Stather, Mr. R. H. Tiddeman, and Mr. W. T. Tucker.	17 16 6
To enable Dr. A. Vaughan to continue his researches on the faunal succession in the Carboniferous Limestone in the British Isles.	*Chairman.*—Prof. J. W. Gregory. *Secretary.*—Dr. A. Vaughan. Dr. Wheelton Hind and Prof. W. W. Watts.	10 0 0
Making experiments for improving the construction of practical standards for use in electrical measurements.	*Chairman.*—Lord Rayleigh. *Secretary.*—Dr. R. T. Glazebrook. Lord Kelvin, Prof. W. E. Ayrton, Prof. J. Perry, Prof. W. G. Adams, Prof. G. Carey Foster, Sir Oliver Lodge, Dr. A. Muirhead, Sir W. H. Preece, Prof. A. Schuster, Dr. J. A. Fleming, Prof. J. J. Thomson, Dr. W. N. Shaw, Dr. J. T. Bottomley, Rev. T. C. Fitzpatrick, Dr. G. Johnstone Stoney, Prof. S. P. Thompson, Mr. J. Rennie, Principal E. H. Griffiths, Sir A. W. Rücker, Prof. H. L. Callendar, Mr. G. Matthey, Mr. A. P. Trotter, Mr. T. Mather, and Mr. F. E. Smith.	50 10 8
Corresponding Societies Committee for the preparation of their report.	*Chairman.*—Mr. W. Whitaker. *Secretary.*—Mr. F. W. Rudler. Rev. J. O. Bevan, Sir Edward Brabrook, Dr. H. T. Brown, Dr. J. G. Garson, Principal E. H. Griffiths, Mr. T. V. Holmes, Mr. J. Hopkinson, Prof. R. Meldola, Dr. H. R. Mill, Mr. C. H. Read, Rev. T. R. R. Stebbing, Prof. W. W. Watts, and the President and General Officers of the Association.	25 0 0
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* *Report of the Seventy-seventh Meeting of the British Association for the Advancement of Science, Leicester, August, 1907*, 1908, page cxviii.

2.—NOT RECEIVING GRANTS OF MONEY.

Subject for Investigation or Purpose.	Members of the Committee.
The consideration of the teaching of elementary mechanics, and the improvement which might be effected in such teaching.	*Chairman.*—Prof. Horace Lamb. *Secretary.*—Prof. J. Perry. Mr. C. Vernon Boys, Prof. Chrystal, Prof Ewing, Prof. G. A. Gibson, Prof. Greenhill, Principal Griffiths, Prof. Henrici, Dr E. W. Hobson, Mr. C. S. Jackson, Sir Oliver Lodge, Prof. Love, Prof. Minchin, Prof. Schuster, Prof. A. M. Worthington and Mr. A. W. Siddons.
To continue the magnetic survey of South Africa commenced by Prof. Beattie and Prof. Morrison.	*Chairman.*—Sir David Gill. *Secretary.*—Prof. J. C. Beattie. Mr. S. S. Hough, Prof. Morrison and Prof. A. Schuster.
The collection, preservation, and systematic registration of photographs of geological interest.	*Chairman.*—Prof. J. Geikie. *Secretary.*—Prof. W. W. Watts. Dr. T. Anderson, Mr. G. Bingley, Dr. T. G. Bonney, Mr. H. Coates, Mr. C. V. Crook, Prof. E. J. Garwood, Mr. W. Gray, Mr. W. J. Harrison, Mr. R. Kidston, Mr. A. S. Reid, Prof. S. H Reynolds, Mr. J. J. H. Teall, Mr. R. Welch and Mr. H. B. Woodward.
To investigate and report on the correlation and age of South African strata and on the question of a uniform stratigraphical nomenclature.	*Chairman.*—Prof. J. W. Gregory. *Secretary.*—Prof. A. Young Mr. W. Anderson, Prof. R. Broom, Dr. G. S. Corstorphine, Mr. Walcot Gibson, Dr. F. H. Hatch, Mr. T. H. Holland, Mr. H. Kynaston, Mr F. P. Mennell, Dr. Molengraaff, Mr. A. J. C. Molyneux, Mr. A. W. Rogers, Mr. E H. L. Schwarz and Prof. R. B. Young.
To determine the precise significance of topographical and geological terms used locally in South Africa.	*Chairman.*—Mr. G. W. Lamplugh. *Secretary.*—Dr. F. H. Hatch. Dr. G. Corstorphine, Mr. A. Du Toit, Mr. A. P. Hall, Mr. G. P. Kynaston, Mr. F. P. Mennell and Mr. A. W. Rogers.
The investigation of gaseous explosions, with special reference to temperature.	*Chairman.*—Sir W. H. Preece. *Secretaries.*—Mr. Dugald Clerk and Prof. B. Hopkinson. Prof F. Birstall, Prof. E G. Coker, Prof. H. B. Dixon, Dr. J. A. Harker, Prof. H. S. Hele-Shaw, Colonel H. C. L. Holden and Prof. A. Smithells.
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[illegible]							
Canada, Royal Astronomical Society of, 1884	[illegible]						
Caradoc and Severn Valley Field-club, 1893	[illegible]						
Cardiff Naturalists' Society, 1867	[illegible]						
Chester Society of Natural Science, Literature, and Art, 1871	[illegible]						
Cornwall, Royal Geological Society of, 1814	[illegible]						
Cornwall Royal Polytechnic Society, 1833	[illegible]						
Croydon Natural History and Scientific Society, 1870	[illegible]						
Dorset Natural History and Antiquarian Field-club, 1875	[illegible]						

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1907-1908.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Dublin Naturalists' Field-club, 1885 ..	Dublin N. F. C.	J. de W. Hinch, National Library of Ireland, Dublin, and F. O'B. Ellison, M.D.	130	5s. Associates, none	5s. Associates, 2s. 6d.	*Irish Naturalist*, monthly. Report, annually.
Dumfriesshire and Galloway Natural History and Antiquarian Society, 1862	Dum. Gall. N. H. A. Soc.	S. Arnott, Sunnymead, Dumfries ..	212	None	5s.	Transactions and Proceedings, annually.
East Kent Scientific and Natural History Society, 1857	E. Kent S. N. H. Soc...	A. Lander, The Medical Hall, Canterbury.	97	None	10s. and 5s.	Transactions, annually.
Eastbourne Natural History Society, 1867	Eastbourne N. H. Soc.	Henry Sparks, Villa Ruhe, 5, St. Leonard's Road, Eastbourne.	120	2s. 6d.	7s. 6d.	Transactions, biennially.
Edinburgh Field-naturalists' and Microscopical Society, 1869.	Edin. F. N. Mic. Soc. ..	John Thomson, 21, St. Ninian's Terrace, Edinburgh	230	5s.	5s.	Transactions, annually.
Edinburgh Geological Society, 1834..	Edinb. Geol. Soc. ..	India Buildings, Edinburgh. David Gloag.	243	10s. 6d.	12s. 6d.	Transactions, annually.
Elgin and Morayshire Literary and Scientific Association, 1836	Elgin Lit. Sci. Assoc. ..	Norris Mackay, W.S., Elgin.	196	None	5s.	Transactions, occasionally.
Essex Field-club, 1880	Essex F. C.	William Cole, Springfield, Epping New Road, Buckhurst Hill, Essex.	300	None	15s.	*Essex Naturalist*, quarterly; *Year-book*, annually; *Special Memoirs, &c.*, occasionally.
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc. ..	Peter Macnair, F.R.S.E., 207, Bath Street, Glasgow.	300	None	10s.	Transactions, biennially.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc. ..	Alex. Ross, 409, Great Western Road, Glasgow.	295	None	7s. 6d.	Transactions and Proceedings, annually.
Glasgow, Royal Philosophical Society of, 1802	Glasgow R. Phil. Soc. ..	Prof. Peter Bennett, 207, Bath Street, Glasgow.	1,000	£1 1s.	£1 1s.	Proceedings, annually.
Halifax Scientific Society, 1874 .	Halifax S. S. ..	F. Barker, 11, Hall Street, Halifax	143	None	2s. 6d.	—
Hampshire Field-club and Archæological Society, 1885	Hants F. C.	W. Dale, F.S.A., F.G.S., The Lawn, Archer's Road, Southampton.	250	None	7s. 6d.	Proceedings, annually.
Hertfordshire Natural History Society and Field-club, 1875	Herts. N. H. Soc. ..	A. E. Gibbs, F.L.S., St. Albans, and A. Sutton, Watford.	160	10s.	10s.	Transactions, twice a year.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C. ..	G. F. Pollard, F.Z.S., 170, Station Road, Redhill.	94	None	10s. and 5s.	Proceedings, every two or three years.
Hull Geological Society, 1887	Hull Geol. Soc. .. .	J. W. Stather, F.G.S., Newland Park, Hull	72	None	5s.	Transactions, annually.
Hull Scientific and Field-naturalists' Club, 1886	Hull Sci. F. N. C. ..	T. Stainforth, The Museum, Hull.	180	None	5s.	Transactions, annually.
Institution of Mining Engineers, 1889	Inst. Min. Eng. ..	Secretary, Neville Hall, Newcastle-upon-Tyne.	3,300	None	None	Transactions, monthly.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland ..	Dr. W. Lawson, Dr. N. M. Falkiner and C. H. Oldham, 35, Molesworth Street, Dublin.	100	None	£1.	Journal, annually.

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Andersonian Naturalists' Society, 1885	Andersonian Nat. Soc.	Technical College, Glasgow. R. Barnett Johnstone and Arch. Park.	323	None	2s. 6d.	Annals, occasionally.
Ashmolean Natural History Society of Oxfordshire, 1880		F. A. Bellamy, 4, St. John's Road, Oxford.	351	None	5s.	Report, annually.
Bath Natural History and Antiquarian Field-club, 1855	Bath N. H. A. F. C. ..	J. Langfield Ward, Royal Literary and Scientific Institution, Bath.	60	5s.	10s.	Proceedings, annually.
Belfast Natural History and Philosophical Society, 1821	Belfast N. H. Phil. Soc.	Museum, College Square. R. M. Young, M.R.I.A.	210	None	£1 1s.	Report and Proceedings, annually.
Belfast Naturalists' Field-club, 1863 ..	Belfast Nat. F. C. ..	Museum, College Square. W. H. Galloway	410	5s.	5s.	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831 ..	Berwicksh. Nat. Club ..	Rev. J. J. M. L. Aiken, B.D., Manse of Ayton, Berwickshire.	400	10s	8s. 6d.	*History of the Berwickshire Naturalists' Club*, annually.
Birmingham and Midland Institute Scientific Society, 1859	Birm. & Mid. Inst. Sci. Soc.	Alfred Cresswell, Birmingham and Midland Institute, Paradise Street, Birmingham.	132	None	10s. 6d. and 5s.	Records of Meteorological Observations, annually.
Birmingham Natural History and Philosophical Society, 1858	Birm. N. H. Phil. Soc.	Avebury House, Newhall Street, Birmingham. W. B. Grove, M.A., and H. G. Perkins.	190	None	£1 1s.	Proceedings, occasionally.
Brighton and Hove Natural History and Philosophical Society, 1854	Brighton N. H. Phil. Soc.	J. Colbatch Clark, 9, Marlborough Place, Brighton.	160	None	10s.	Report, annually.
Bristol Naturalists' Society, 1862 ..	Bristol Nat. Soc. ..	J. H. Priestley, B.Sc., University College, Bristol.	160	5s.	10s. and 5s.	Proceedings, annually.
British Mycological Society, 1896 ..	British Mycol. Soc. ..	Carleton Rea, 34, Foregate Street, Worcester.	70	None	10s.	Transactions, annually.
Buchan Field-club, 1887	Buchan F. C.	J. F. Tocher, F.I.C., 5, Chapel Street, Peterhead.	170	5s.	5s.	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	Burt. N. H. Arch. Soc. ..	H. Lloyd Hind, B.Sc., 53, Stanton Road, Burton-on-Trent.	200	None	5s.	Report, annually; Transactions, occasionally.
Canada, Royal Astronomical Society of, 1884	Roy. Astr. Soc. of Canada	Canadian Institute Building, Toronto. J. R. Collins.	400	None	2 dollars.	Journal, bi-monthly.
Caradoc and Severn Valley Field-club, 1893	Car. & Sev. Vall. F. C. ..	H. E. Forrest, 37, Castle Street, Shrewsbury.	202	5s.	5s.	Transactions and Record of Bare Facts, annually.
Cardiff Naturalists' Society, 1867 ..	Cardiff Nat. Soc. ..	W. Gilbert Scott, 25, Duke Street, Cardiff	400	None	12s. 6d.	Transactions, annually.
Chester Society of Natural Science, Literature, and Art, 1871	Chester Soc. Nat. Sci. ..	Grosvenor Museum, Chester. G. P. Miln and F. Simpson.	1073	None	5s.	Report and Proceedings, annually.
Cornwall, Royal Geological Society of, 1814	Cornw. R. Geol. Soc. ..	The Museum, Public Buildings, Penzance. John B. Cornish.	98	None	£1 1s.	Transactions, annually.
Cornwall Royal Polytechnic Society, 1833.	Cornwall R. Poly Soc.	E. W. Newton, Camborne, Cornwall.	300	None	10s. upwards.	Report annually.
Croydon Natural History and Scientific Society, 1870	Croydon N. H. Soc. ..	Public Hall, Croydon. G. W. Moore.	167	None	10s.	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field-club, 1875	Dorset N. H. A. F. C. ..	Rev. Herbert Pentin, M.A., M.R.A.S., Milton Abbey Vicarage, Dorset.	400	10s.	10s., 8s. and 2s. 6d.	Proceedings, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1907-1908.—*Continued.*

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Dublin Naturalists' Field-club, 1885	Dublin N. F. C.	J. de W. Hinch, National Library of Ireland, Dublin, and F. O'B. Ellison, M.D.	130	5s. Associates, none	5s. Associates, 2s. 6d.	*Irish Naturalist*, monthly. Report, annually.
Dumfriesshire and Galloway Natural History and Antiquarian Society, 1862	Dum. Gall. N. H. A. Soc.	S. Arnott, Sunnymead, Dumfries	212	None	5s.	Transactions and Proceedings, annually.
East Kent Scientific and Natural History Society, 1857	E. Kent S. N. H. Soc.	A. Lander, The Medical Hall, Canterbury.	97	None	10s. and 5s.	Transactions, annually.
Eastbourne Natural History Society, 1867	Eastbourne N. H. Soc.	Henry Sparks, Villa Ruhe, 5, St. Leonard's Road, Eastbourne.	120	2s. 6d.	7s. 6d.	Transactions, biennially.
Edinburgh Field-naturalists' and Microscopical Society, 1869.	Edin. F. N. Mic. Soc.	John Thomson, 21, St. Ninian's Terrace, Edinburgh	230	5s.	5s.	Transactions, annually.
Edinburgh Geological Society, 1834	Edinb. Geol. Soc.	India Buildings, Edinburgh. David Ghong.	243	10s. 6d.	12s. 6d.	Transactions, annually.
Elgin and Morayshire Literary and Scientific Association, 1836	Elgin Lit. Sci. Assoc.	Norris Mackay, W.S., Elgin.	196	None	5s.	Transactions, occasionally.
Essex Field-club, 1880	Essex F. C.	William Cole, Springfield, Epping New Road, Buckhurst Hill, Essex.	300	None	15s.	*Essex Naturalist*, quarterly; *Year-book*, annually; *Special Memoirs*, &c., occasionally.
Glasgow, Geological Society of, 1858	Glasgow Geol. Soc.	Peter Macnair, F.R.S.E., 207, Bath Street, Glasgow.	300	None	10s.	Transactions, biennially.
Glasgow, Natural History Society of, 1851	Glasgow N. H. Soc.	Alex. Ross, 409, Great Western Road, Glasgow.	295	None	7s. 6d.	Transactions and Proceedings, annually.
Glasgow, Royal Philosophical Society of, 1802	Glasgow R. Phil. Soc.	Prof. Peter Bennett, 207, Bath Street, Glasgow.	1,000	£1 1s.	£1 1s.	Proceedings, annually.
Halifax Scientific Society, 1874	Halifax S. S.	F. Barker, 11, Hall Street, Halifax	143	None	2s. 6d.	—
Hampshire Field-club and Archæological Society, 1885	Hants F. C.	W. Dale, F.S.A., F.G.S., The Lawn, Archer's Road, Southampton	250	None	7s. 6d.	Proceedings, annually.
Hertfordshire Natural History Society and Field-club, 1875	Herts. N. H. Soc.	A. E. Gibbs, F.L.S., St. Albans, and A. Sutton, Watford.	160	10s.	10s.	Transactions, twice a year.
Holmesdale Natural History Club, 1857	Holmesdale N. H. C.	G. F. Pollard, F.Z.S., 170, Station Road, Redhill.	94	None	10s. and 5s.	Proceedings, every two or three years.
Hull Geological Society, 1887	Hull Geol. Soc.	J. W. Stather, F.G.S., Newland Park, Hull.	72	None	5s.	Transactions, annually.
Hull Scientific and Field-naturalists' Club, 1886	Hull Sci. F. N. C.	T. Stainforth, The Museum, Hull.	180	None	5s.	Transactions, annually.
Institution of Mining Engineers, 1889	Inst. Min. Eng.	Secretary, Neville Hall, Newcastle-upon-Tyne	3,300	None	None	Transactions, monthly.
Ireland, Statistical and Social Inquiry Society of, 1847	Stat. Soc. Ireland	Dr. W. Lawson, Dr. N. M. Falkiner and C. H. Oldham, 35, Molesworth Street, Dublin.	100	None	£1.	Journal, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1907–1908.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Leeds Geological Association, 1873 ..	Leeds Geol. Assoc. ..	E. Hawkesworth, Crossgates, Leeds.	87	None	5s.	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Leicester Lit. Phil. Soc.	Corporation Museum. W. A. Evans, 24, Fosse Road South, Leicester.	350 Members & Associates.	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions, half-yearly.
Liverpool Biological Society, 1886 ..	Liverpool Biol. Soc. ..	J. A. Clubb, M.Sc., Free Public Museum, Liverpool.	95	10s. 6d. and 2s. 6d.	£1 1s. and 10s. 6d.	Proceedings and Transactions annually.
Liverpool Engineering Society, 1875 ..	Liverpool E. Soc. ..	R. C. F. Annett, 4, Buckingham Avenue, Sefton Park, Liverpool.	550	None	£1 1s. and 10s. 6d.	Transactions and Report, annually.
Liverpool Geographical Society, 1891	Liverpool Geog. Soc. ..	Capt. E. C. Dubois Phillips, R.N., 14, Hargreave's Buildings, Liverpool.	640	None	Members, £1 1s.; Associates, 10s. 6d.	Transactions and Report, annually.
Liverpool Geological Society, 1858 ..	Liverpool Geol. Soc ..	Royal Institution. W. A. Whitehead, B.Sc.	70	None	£1 1s. and 10s. 6d.	Proceedings, annually.
London: Quekett Microscopical Club, 1865	Quekett Club	W. B. Stokes, 4, Winn Road, Lee, S.E.	403	None	10s.	Journal, half-yearly.
Man, Isle of, Natural History and Antiquarian Society, 1879	I. of Man N. H. A. Soc.	Armitage Rigby, 23, Athol Street, Douglas, Isle of Man.	111	2s. 6d.	7s. 6d. and 5s.	Proceedings, three times a year. Transactions, occasionally.
Manchester Geographical Society, 1884	Manch. Geog. Soc. ..	F. Zimmern and J. H. Reed, 16, St. Mary's Parsonage, Manchester.	600	None	Members, £1 1s.; Associates, 10s. 6d.	Journal, quarterly.
Manchester Geological and Mining Society, 1838	Manch. Geol. Min. Soc.	5, John Dalton Street, Manchester. Sydney A. Smith.	300	None	£2 2s., £1 5s., £1 1s. and £1	*Transactions of The Institution of Mining Engineers*, monthly.
Manchester Microscopical Society, 1880	Manch. Mic. Soc. ..	E. C. Stump, Malmesbury, Polefield, Blackley.	217	5s.	6s.	Transactions and Report, annually.
Manchester Statistical Society, 1833 ..	Manch. Stat. Soc. ..	Theodore Gregory, 3, York Street, Manchester.	191	10s. 6d.	10s. 6d.	Transactions, annually.
Marlborough College Natural History Society, 1864	Marlb. Coll. N. H. Soc.	Marlborough College. E. Meyrick, F.R.S.	280	1s. 6d.	3s. and 5s.	Report, annually.
Midland Counties Institution of Engineers, 1871	Mid. Count. Inst. ..	G. Alfred Lewis, M.A., Albert Street, Derby.	420 Membs., Associates, & Students	£1 1s. None	Members £1 11s. 6d.; Associates and Students, £1.	*Transactions of The Institution of Mining Engineers*, monthly.
Midland Institute of Mining, Civil, and Mechanical Engineers, 1869	Mid. Inst. Eng.	L. T. O'Shea, The University, Sheffield.	306	None	£1 10s.	*Transactions of The Institution of Mining Engineers*, monthly.
Norfolk and Norwich Naturalists' Society, 1869	Norf. Norw. Nat. Soc.	W. A. Nicholson, St. Helen's Square, Norwich.	277	None	6s.	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	N. Eng. Inst.	Secretary, Neville Hall, Newcastle-upon-Tyne.	1,350	None	£1 5s. and £2 2s.	*Transactions of The Institution of Mining Engineers*, monthly
North Staffordshire Field-club, 1865	N. Staffs. F. C. .. .	W. Wells Bladen, Stone, Staffs.	527	5s.	5s.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field-club, 1876	Northants. N. H Soc...	H. N. Dixon, M.A., 23, East Park Parade, Northampton.	210	None	10s.	Journal, quarterly.
Northumberland, Durham, and Newcastle-upon-Tyne, Natural History Society of, 1829	Northumb. N. H. Soc...	Hancock Museum, Newcastle-upon-Tyne. N. H. Martin, F.L.S., and C. E. Robson.	430	None	£1 1s.	Transactions, annually.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1907–1908.—*Continued.*

Full Title and Date of Foundation.	Abbreviated Title.	Head-quarters or Name and Address of Secretary.	No. of Members.	Entrance Fee.	Annual Subscription.	Title and Frequency of Issue of Publications.
Nottingham Naturalists' Society, 1852	Nott. Nat. Soc.	Prof. J. W. Carr, M.A., University College, Nottingham.	182	2s. 6d.	5s.	Report and Transactions, annually.
Paisley Philosophical Institution, 1808	Paisley Phil. Inst. ..	J. Gardner, 3 County Place, Paisley	570	5s.	7s. 6d.	Report and Meteorological Observations, annually.
Perthshire Society of Natural Science, 1867	Perths. Soc. N. Sci. ..	Tay Street, Perth. S. T. Ellison ..	390	2s. 6d.	5s. 6d.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	Rochdale Lit. Sci. Soc.	J. Reginald Ashworth, D.Sc., 105, Freehold Street, Rochdale.	244	None	6s.	Transactions, biennially.
Rochester Naturalists' Club, 1878 ..	Rochester N. C.	John Hepworth, Linden House, Rochester.	163	None	5s.	*Rochester Naturalist*, quarterly.
Somersetshire Archæological and Natural History Society, 1849	Som'setsh. A.N.H. Soc.	The Castle, Taunton Rev. F. W. Weaver, Rev. E. H. Bates and C. Tite.	676	10s. 6d.	10s. 6d.	Proceedings, annually.
South African Philosophical Society, 1877	S. African Phil. Soc. ..	G. M. Clark, South African Museum, Cape Town.	207	None	£2	Transactions, occasionally.
South-Eastern Union of Scientific Societies, 1896	S.-E. Union	Rev. R. Ashington Bullen, Englemoor, Heathside Road, Woking	49 Societies	None	Minimum 5s.	*South-Eastern Naturalist*, annually.
Southport Literary and Philosophical Society	Southport Lit. and Phil. Soc.	Arthur Quayle, 409, Lord Street, Southport.	135	None	7s. 6d.	Proceedings, annually.
South Staffordshire and Warwickshire Institute of Mining Engineers, 1867	S. Staffs. Inst. Eng. ..	G. D. Smith, 3, Newhall Street, Birmingham.	174	£1 1s. and 10s. 6d.	£1 11s. 6d. and £1 1s.	*Transactions of The Institution of Mining Engineers*, monthly.
Tyneside Geographical Society, 1887 ..	Tyneside Geog. Soc. ..	Geographical Institute, St. Mary's Place, Newcastle-upon-Tyne. Herbert Shaw, B.A., F.R.G.S.	1,000	None	10s.	Journal, annually.
Vale of Derwent Naturalists' Field-club, 1887	Vale of Derwent Nat. F. C.	W. Johnson, Byer Moor, Burnopfield, Co. Durham.	122	None	2s. 6d.	Transactions, occasionally.
Warwickshire Naturalists' and Archæologists' Field-club, 1854	Warw. N. A. F. C. ..	Museum, Warwick. C. West, Cross Cheaping, Coventry.	80	2s. 6d.	5s.	Proceedings, annually
Woolhope Naturalists' Field-club, 1851	Woolhope N. F. C. ..	Woolhope Club-room, Free Library, Hereford. H. Cecil Moore.	260	10s.	10s.	Transactions, biennially.
Worcestershire Naturalists' Club, 1847		Victoria Institute, Worcester. Wm. H. Edwards.	107	10s.	5s.	Transactions, annually.
Yorkshire Geological Society, 1837 ..	Yorks. Geol. Soc. ..	J. H. Howarth, F.G.S., Somerley, Rawson Avenue, Halifax	214	None	13s.	Proceedings, annually.
Yorkshire Naturalists' Union, 1861 ..	Yorks. Nat. Union ..	The Museum, Hull. T. Sheppard, F.G.S.	478 and 3,368 Associates	None	10s. 6d.	Transactions, annually; *The Naturalist*, monthly.
Yorkshire Philosophical Society, 1822	Yorks. Phil. Soc. ..	Museum, York. Dr. Tempest Anderson and C. E. Elmhirst.	480	None	£2	Report, annually.

CATALOGUE OF THE MORE IMPORTANT PAPERS, AND ESPECIALLY THOSE REFERRING TO LOCAL SCIENTIFIC INVESTIGATIONS, PUBLISHED BY THE CORRESPONDING SOCIETIES DURING THE YEAR ENDING MAY 31ST, 1907.

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

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BEDSON, DR. P. P., and HENRY WIDDAS. "Experiments illustrative of the Inflammability of Mixtures of Coal-dust and Air." *Trans. Inst. Min. Eng.*, vol. xxxii., pages 529-531, 1907.

COOKE, A. E. (N. Staff. Inst. Eng.). "Notes on the Feed-Water of Colliery-Boilers," *Trans. Inst. Min. Eng.*, vol. xxxii., pages 31-37, 1906.

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BARKE, F. "Report of the Geological Section." *Trans. N. Staff. F. C.*, vol. xli., pages 91-92, 1907.

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BURNETT, ARTHUR. "Notes on the Upper Chalk of Lincolnshire." *The Naturalist for 1906*, pages 207-212, 1906.

BURTON, F. M. "Note on a Liassic Concretion." *The Naturalist for 1907*, pages 149-150, 1907.

BURTON, W. J. P. "The Ancient Volcanoes of Derbyshire." *Trans. Burton-on-Trent N. H. Arch. Soc.*, vol. v., pages 95-107, 1907.

BUTTERFIELD, A. E. "Islands in the Humber." *Trans. Hull Geol. Soc.*, vol. vi., pages 33-37, 1906.

DWERRYHOUSE, DR. A. R. "Report on the Magnesian Limestone Committee." *Trans. Leeds Geol. Assoc.*, vol. xiii., pages 45-48, 1906.

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Section F.—ECONOMIC SCIENCE AND STATISTICS.

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Section H.—ANTHROPOLOGY.

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Section I.—PHYSIOLOGY.

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Section K.—BOTANY.

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INDEX TO VOL. XXXIV.

EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and the Surname; or, in the case of the name of any Firm, Association or Institution, the full name of such Firm, etc.

Discussions are printed in *italics*.

The following contractions are used:—

M. C.—The Midland Counties Institution of Engineers.

M. G.—Manchester Geological and Mining Society.

M. I.—Midland Institute of Mining, Civil and Mechanical Engineers.

N. E.—The North of England Institute of Mining and Mechanical Engineers.

N. S.—The North Staffordshire Institute of Mining and Mechanical Engineers.

S. I.—The Mining Institute of Scotland.

S. S.—The South Staffordshire and Warwickshire Institute of Mining Engineers.

A.

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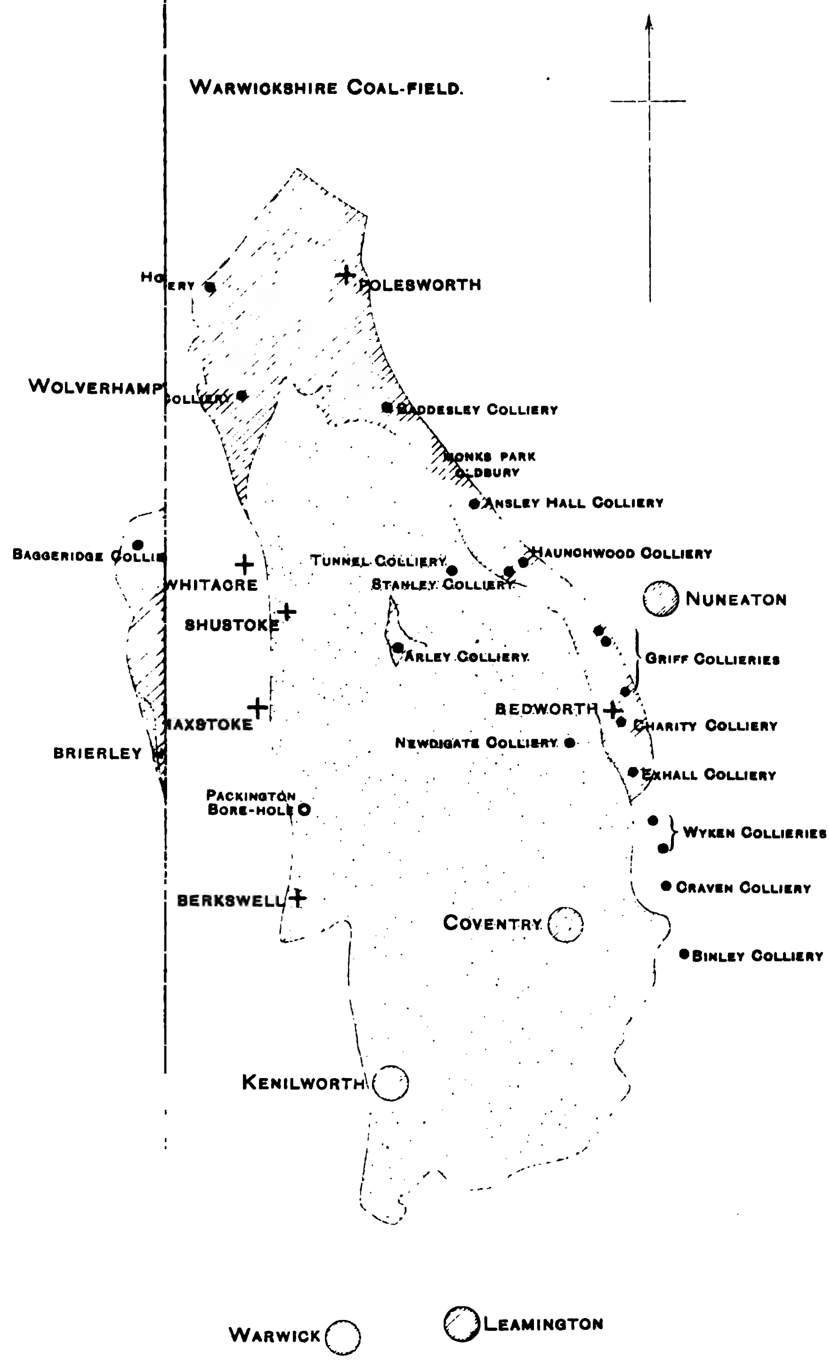
...NGHAM BASIN AND RELATIVE POSITIONS OF
...D WARWICKSHIRE COAL-FIELDS.



The Institution of Mining Engineers
Transactions 1907-1908.

Vol. XXXIV. Plate III.

To illustrate Mr. W. Roulledge's Paper on "Winding-ropes and Capels."

Ordinary Capel.

Fig. 1.—Side View.

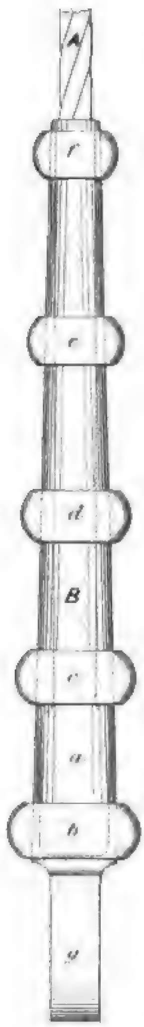
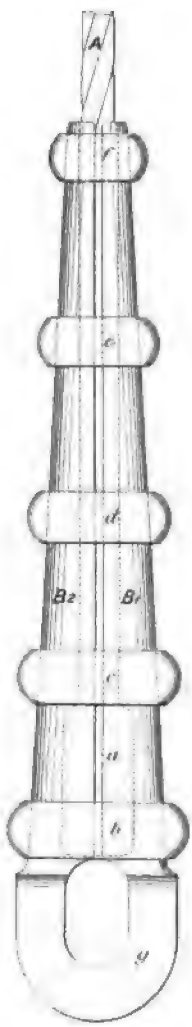


Fig. 2.—End View.



Cone Capel.

Fig. 3.—Side View.

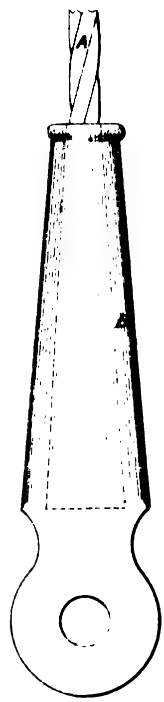
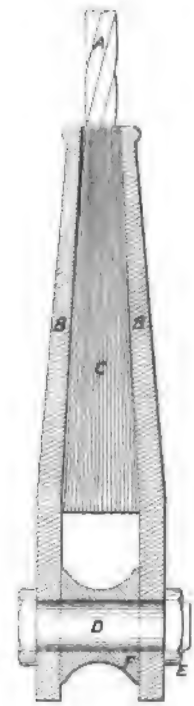


Fig. 4. Cross Section

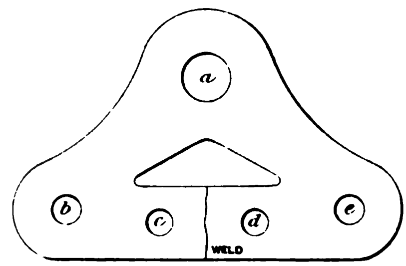


Scale, 1 Foot to 1 Inch.

Bridle for connecting Cage-chains.

Fig. 5.—Side View.

Fig. 6.—Plan.



Midland Institute of Mining Civil & Mechanical Engineers
Transactions 1907-1908.

Vol. XVIII. Plate IV.

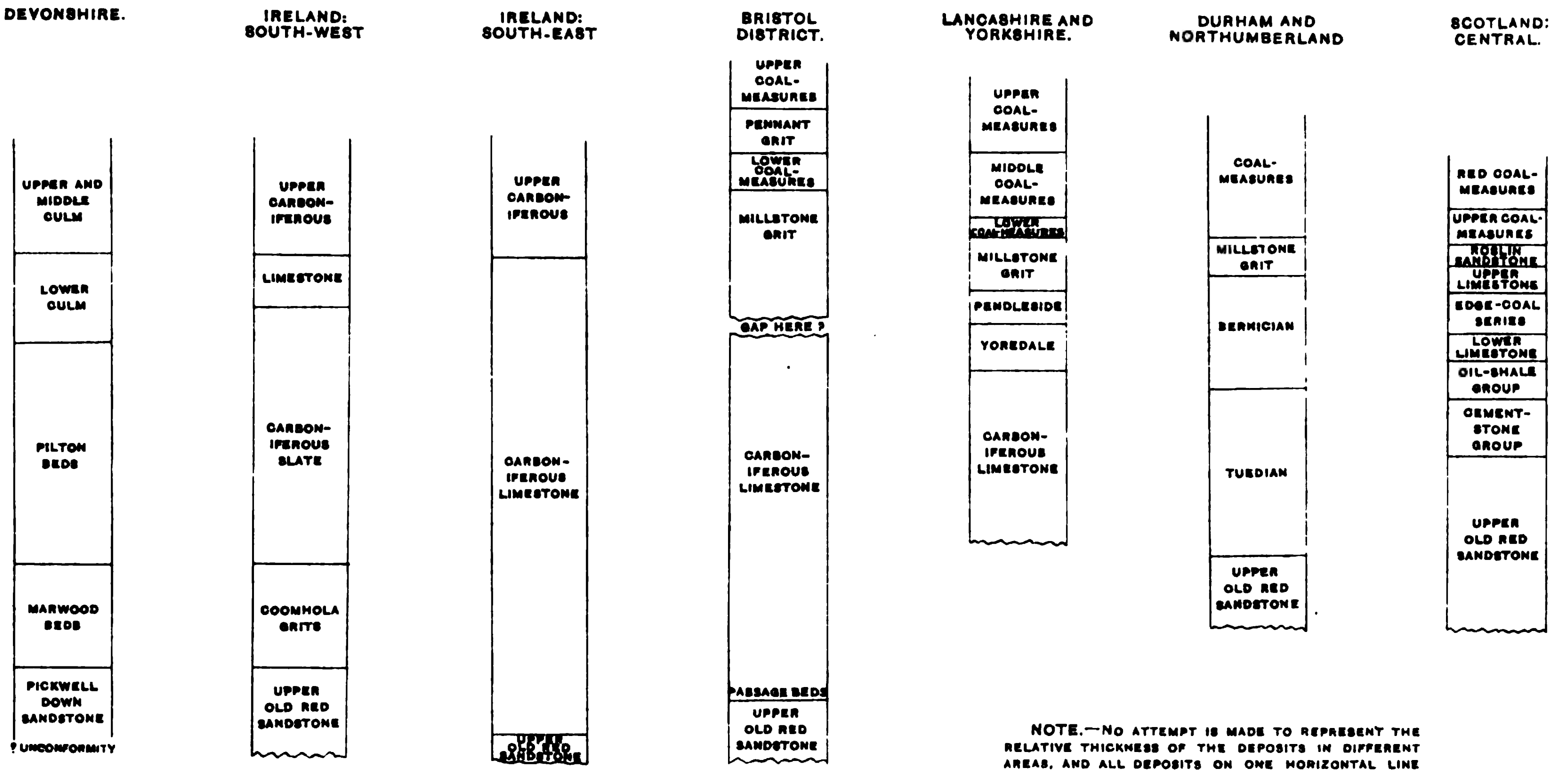
Andw Reid & Compy Ltd Newcastle upon Tyne

The Institution of Mining Engineers.
Transactions. 1907-1908

To illustrate Mr. G. Hickling's Paper on "Carboniferous Flora," etc

Vol. XXXIV., Plate IV.

Fig. 1.—Table of the Equivalence in Time of the Carboniferous Rocks in various parts of Great Britain and Ireland.



Note.—No attempt is made to represent the relative thickness of the deposits in different areas, and all deposits on one horizontal line are presumed to be of the same age.

The Manchester Geological and Mining Society
Transactions 1907-1908

Andw Reid & Compy Ltd Newcastle upon Tyne

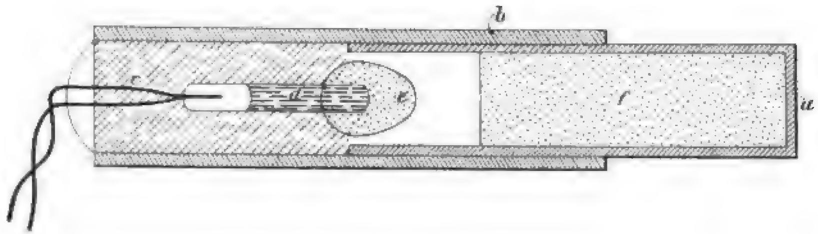
Vol. XXX., Plate V.

The Institution of Mining Engineers.
Transactions.1907.1908

To illustrate Mr. W. Walker's "Notes on Two Incidents with Explosives." etc.

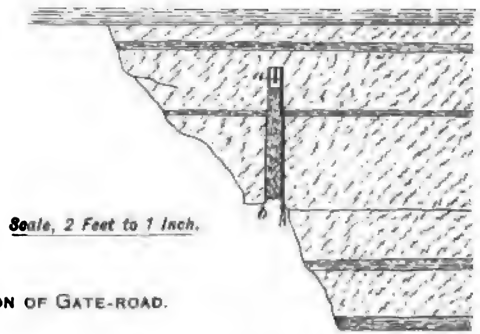
Vol. XXXIV, Plate V.

Fig. 1.—Section of Detonator.



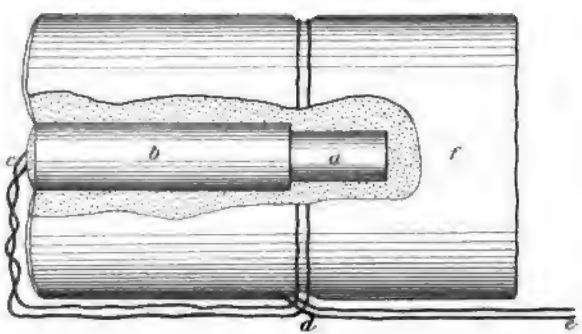
Double Size.

Fig. 2.—Section of Haulage-road.



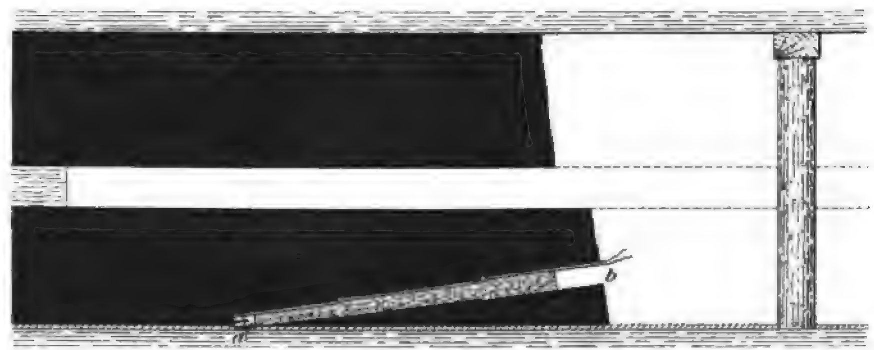
Scale, 2 Feet to 1 Inch.

Fig. 3.—Elevation of Cartridge and Detonator.



Full Size.

Fig. 4.—Section of Gate-road.



Scale, 2 Feet to 1 Inch.

Midland Institute of Mining, Civil & Mechanical Engineers,
Transactions. 1907-1908.

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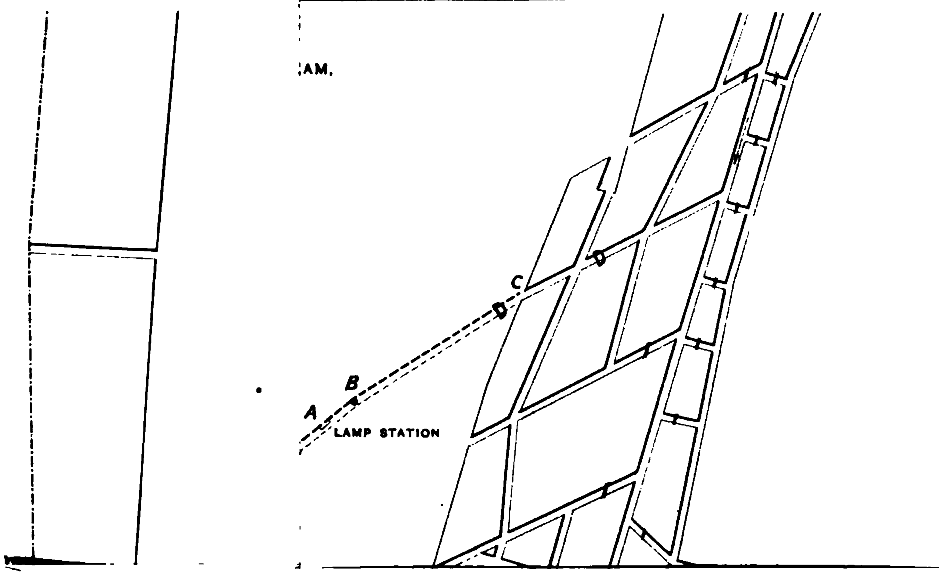
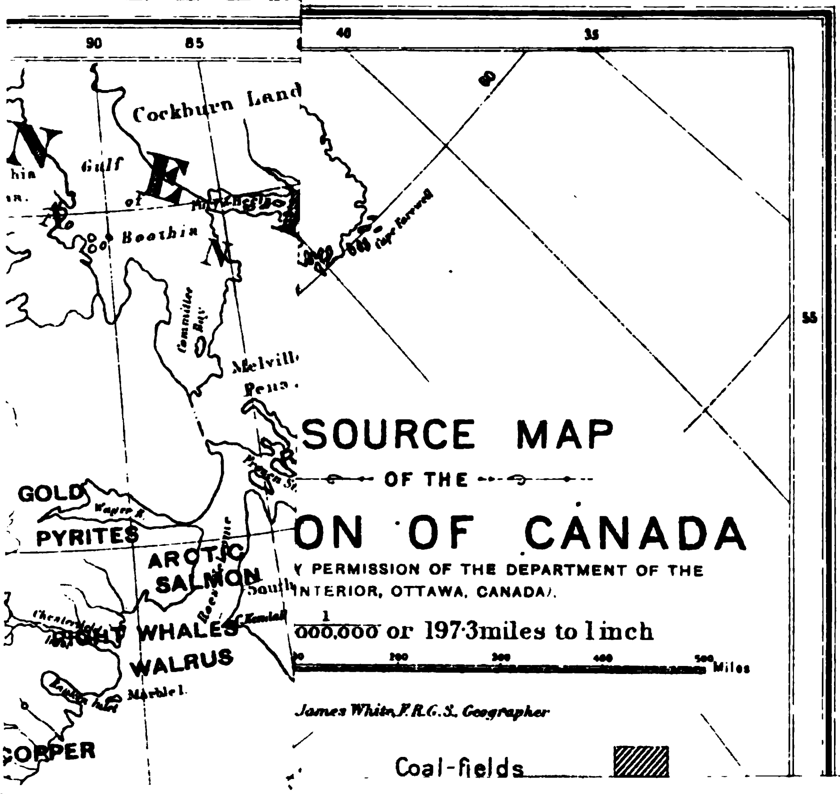
Vol. XVIII, Plate V.

The Institution of Mining Engin[eers]
Transactions.1907-1908

...lust at Middleton Colliery."

...AM.




90
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Boothia
Committee Bay
Melville Pen.
Cape Farewell
GOLD
PYRITES
ARCTIC
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000,000 or 197·3miles to 1 inch
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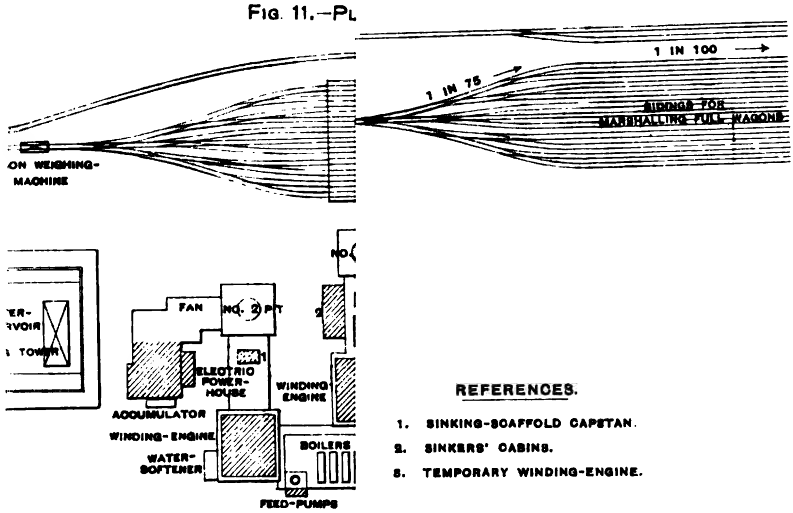
400
500
Miles
James White, F.R.G.S. Geographer
Coal-fields

Fig. 11.—Pl



REFERENCES.

1. SINKING-SCAFFOLD CAPSTAN.
2. SINKERS' CABINS.
3. TEMPORARY WINDING-ENGINE.

...et to 1 Inch.

R O

Fig. 7.—Cross-sectio
in No. 2

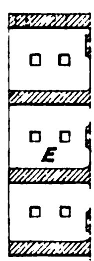
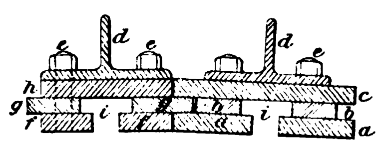
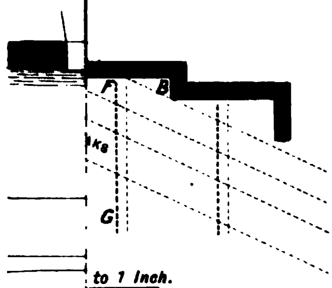


Fig. 4.—Plan of Two Piles.



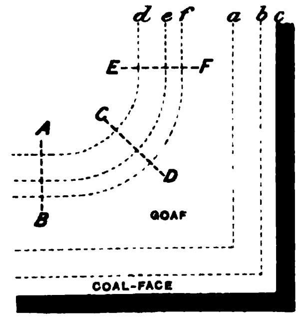
Scale. 1 Foot to 1 Inch.

FIG. PLAN.

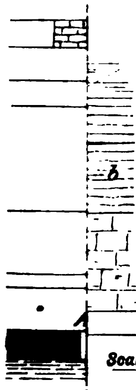


to 1 Inch.

FIG. 7.—PLAN



Scale, 400 Feet to 1 Inch.



Scale, 4 Feet to 1 Inch.

FIG. 9.—SECTION.

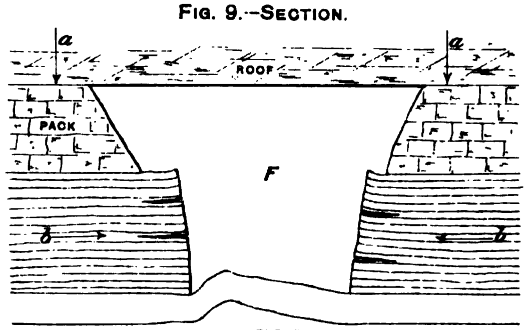


FIG. 12.—CROSS SECTION.

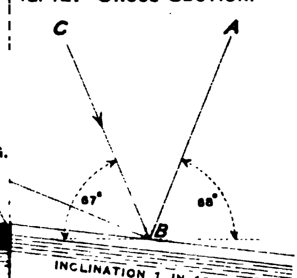


FIG. 13.—CROSS SECTION.

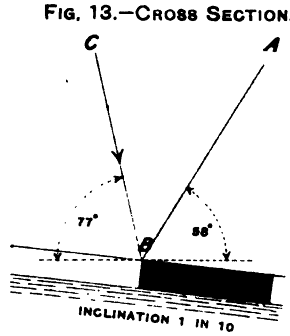


FIG.

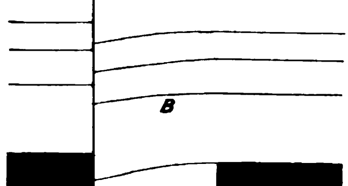
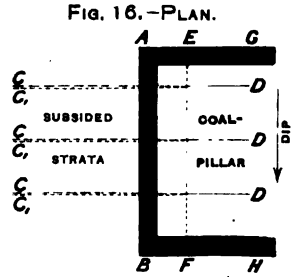
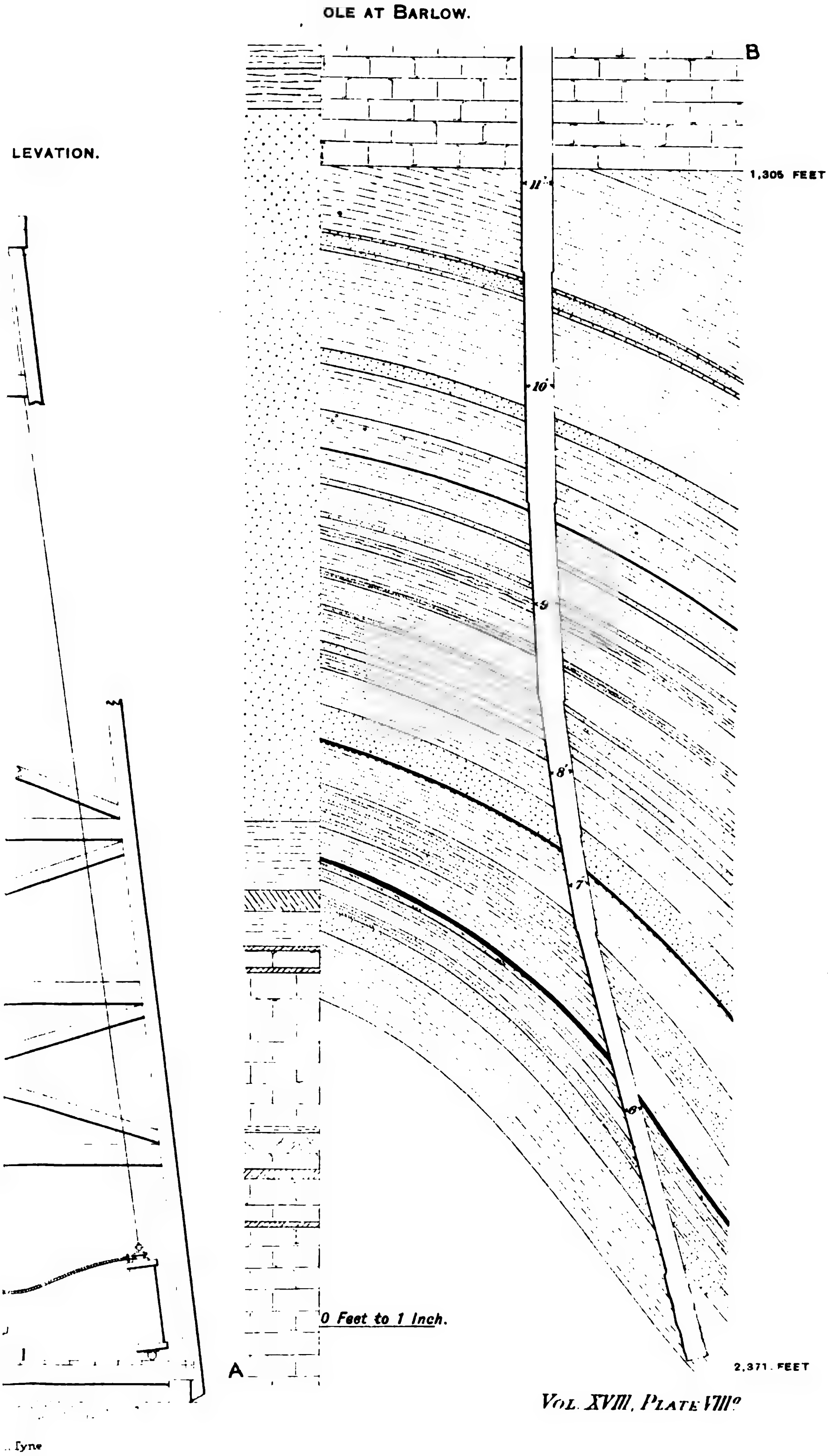


FIG. 16.—PLAN.



Scale, 400 Feet to 1 Inch.


OLE AT BARLOW.
LEVATION.
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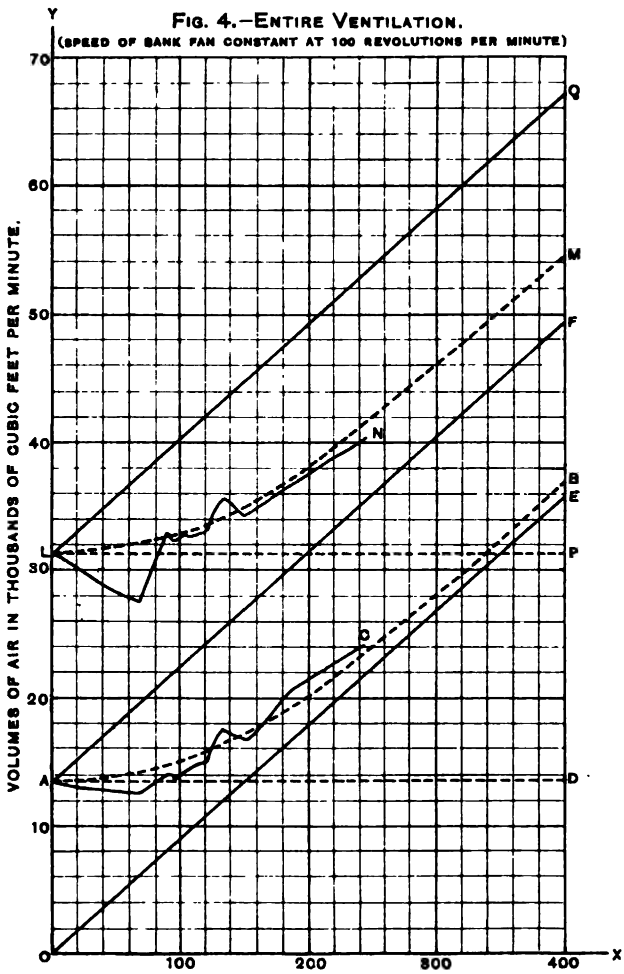
1,305 FEET
11'
10'
9
8'
7'
6'
0 Feet to 1 Inch.
A
2,371. FEET
Tyne

FIG. 4.—ENTIRE VENTILATION.

(SPEED OF BANK FAN CONSTANT AT 100 REVOLUTIONS PER MINUTE)



REVOLUTIONS OF THE BUSTY FAN PER MINUTE.

NOTE.—THIS DIAGRAM IS DRAWN FROM THE VALUES IN TABLE IV.

REFERENCES.

ORDINATE TO A B = THEORETICAL VOLUME FOR BUSTY SEAM, OBTAINABLE FROM BOTH FANS.

DO. TO AC = ACTUAL VOLUME OBTAINED IN THE EXPERIMENTS.

DO. TO OE = VOLUME THE BUSTY FAN WOULD GIVE IF ACTING ALONE.

DO. TO AD = VOLUME THE BANK FAN WOULD DRAW FROM THE BUSTY IF ACTING ALONE.

DO. TO AF = OE + AD = THE POPULAR IDEA OF WHAT THE BUSTY VOLUME SHOULD HAVE BEEN.

DO. TO LM = THE TOTAL VOLUME THEORETICALLY OBTAINABLE FROM BOTH FANS.

DO. TO LN = THE TOTAL VOLUME ACTUALLY OBTAINED.

DO. TO LQ = LP + OE = THE POPULAR IDEA OF WHAT THE TOTAL VOLUME SHOULD HAVE BEEN.

DO. TO LP = THE TOTAL VOLUME THE BANK FAN WOULD GIVE IF ACTING ALONE.